

# **Within and Between Country Price Dispersion in Developing Countries. The Role of Borders, Geography and Exchange Rate Variability**

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## **ABSTRACT**

This paper exploits a panel dataset of prices on 88 traded products across 19 cities in Zimbabwe and South Africa, over the period January 2009 to August 2014. We measure the dispersion to the Law of One Price within and between Zimbabwe and South Africa to investigate price adjustment for the period immediately after the introduction of a new currency in Zimbabwe. We show that price dispersion within Zimbabwe fell sharply for the first 18 months after the introduction of a new currency system, thereafter remaining stable for the remaining period. We argue that the fall in price dispersion is related to the new currency effect. We control for exchange rate volatility on the international market and confirm results from previous findings that international borders matter – the coefficient of exchange rate volatility is positive and statistically significant, implying that higher exchange rate volatility is associated with higher price dispersion. We extend our analysis by controlling for trade (proxied by Zimbabwe imports from South Africa) and show that trade explains some of the variation in prices but does not change yearly dummies by very much.

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## **INTRODUCTION**

How does the introduction of a new currency system, after a period of high inflation, affect product market integration within a country? Inflation distorts price signals and clouds the information contained in these signals. High inflation in turn may mean that the dispersion of prices of similar products is high across the country. A new currency system can end periods of high inflation and re-establish these price signals.

The introduction of a new currency system in Zimbabwe in January 2009 provides an opportunity to examine the adjustment of prices at the end of hyper-inflation in more detail. In this study we demonstrate that a new currency system does have positive effects on the extent to which prices are integrated both within and between countries. Firstly, we measure the dispersion to the Law of One Price within Zimbabwe and its change, over the period immediately after the introduction of a new currency system (January 2009 to August 2014).

We extend the analysis to include South Africa to determine how much of the convergence is driven by prices in Zimbabwe's biggest trading partner. We examine the border effect and how it is related to price dispersion. Our objective is to investigate whether there is substantial evidence that the border narrows overtime and if so, what economic candidates possibly explains it. To do this we use a panel dataset of traded products used in the computation of the Consumer Price Index (CPI) in Zimbabwe and South Africa.

We present evidence that soon after the introduction of a new currency system, price dispersion fell overtime for both within and between Zimbabwe and South Africa although it is still farther away from parity. We show that much of the fall in price dispersion is related to the new currency effect. We control for exchange rate volatility on the international market and confirm results from previous findings that international borders matter – the coefficient of exchange rate volatility is positive and statistically significant, implying that higher exchange rate volatility is associated with higher price dispersion. We argue that both exchange rate volatility and trade have an important impact on the extent to which product markets are integrated both within and between countries although the later tends to have little impact.

## **BACKGROUND AND MOTIVATION**

On 29 January 2009, the Government of Zimbabwe announced a transition to a new currency system dominated by the United States dollar after more than a decade of hyperinflation and economic crisis. The introduction of the new currency system came with additional changes in policies governing inflow of goods<sup>1</sup>. As the then Finance Minister of Zimbabwe Tendai Biti stated in the 2009 budget statement:

*“Following the import liberalisation policy, we have started to witness some benefits in improved supply of goods and services. Prices in foreign exchange which were initially far above import parity levels, reflecting shortages and monopolistic behaviour, have now started to stabilise and in some cases gravitating towards import parity levels. This trend reflects improvement in stocks as well as competition”*

The import liberalisation policy meant increased trade flows and competition for markets between the two countries. Furthermore, increased trade flows and competition led to the re-establishment of information signals particularly on the pricing system which were lost during hyperinflation. Our main aim is to measure the dispersion to the Law of One Price within and between Zimbabwe and South Africa and to investigate the mechanisms through which the fall in price dispersion might have occurred.

Our motivation is driven by this policy change, and also on earlier work by Engel and Rodgers (1996); Parsley and Wei (2001) and Brenton *et al* (2014). For example, in a seminal paper on price dispersion, Engel & Rodgers (1996) show that deviations from the LOP for similar goods increases with distance between city pairs for the United States and Canada and that there is a substantial ‘border effect’ - crossing the border between the US and Canada adds as much volatility to prices as adding “2500 miles” between cities in the same country. Other notable studies which examined the deviations from the LOP in developed and developing economies include Parsley & Wei (2001); Crucini & Shintani (2008); Lee (2010); Reiff & Rumler (2007a); Baba (2014). A few studies have attempted to explore the extent to which markets are integrated in Africa (see Versailles (2012); Balchin (2015); Edwards & Rankin (2012b)).

This new evidence from Africa exploits micro price datasets, used in the computation of the Consumer Price Index (CPI) to examine the extent to which product markets have integrated.

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<sup>1</sup> It is important to note at this stage that the bulk of Zimbabwe’s imports come from South Africa.

The results from this existing body in literature are mixed, with strong evidence confirming earlier findings by Engel & Rodgers (1996) of large and persistent deviations from the LOP both between countries and within countries. While research has been carried out on price dispersion in Africa, there is very little empirical investigations into the effects of a new currency system on price dispersion. This paper will examine how price dispersion evolves in the aftermath of the introduction of a new currency and the end of hyper-inflation.

## THEORETICAL FRAMEWORK ON PRICE DISPERSION

### The Law of One Price: Basic Framework

To provide a framework for our analysis, we follow Engel and Rodgers (1996) by using a Cobb-Douglas production function. Product prices sold by retailer are considered to be a function of both traded and non-traded inputs:

$$P_{i,j} = \beta_{i,j} \alpha_{i,j} (w_{i,j})^{\gamma_i} (q_{i,j})^{1-\gamma_i}$$

Where  $\gamma_i$  is the share of nontraded service in the final output. The price of nontraded service is represented by  $w_{i,j}$  and the price of traded intermediate input is represented by  $q_{i,j}$  and both are determined by competitive markets. Total factor productivity is measured by  $\alpha_{i,j}$  and the mark up over costs  $\beta_{i,j}$  is inversely related to the elasticity of demand. The price of the traded intermediate input  $q_{i,j}$  may vary across locations if there are costs involved in the transportation of the tradable goods. Locations which are also farther apart tend to have different cost structures (Engel & Rogers, 1996).

Therefore, in the absence of arbitrage, buyers faced with a choice to purchase similar products in two different locations will purchase that product from a market which has a lower price subject to transportation costs. With buyers having perfect information, in the long run prices in two different location will equalise subject to transaction costs. This is termed the Law of One Price (LOP). According to the Law of One Price (LOP), identical products sold in different locations  $i$  and  $j$  should cost the same price in the absence of transaction costs. In a simple specification:

$$P_i = P_j + \tau(x_1, x_2, \dots, x_n) + \mu_j$$

The above equation implies that price in location  $i$  should equal price in location  $j$  in the absence of  $\tau(\cdot)$  which includes transaction costs and mark up in location  $j$  ( $\mu_j$ ). The above equation implies that if there is perfect information and the markets are exactly the same, the difference price between location  $i$  and  $j$  are transaction costs. However, in the real world with imperfect information, the markets differ and the difference between the two locations will be transaction costs and other location specific factors.

The measurement of LOP deviations within this framework will be the standard deviation of log price differences in product prices as in Engel and Rodgers (1996) and Parsley and Wei (2001). The insight here is that price dispersion is a linear combination of differences in nontraded and traded input prices as well as the production share of the non-traded share in the final output. Price dispersion is also influenced by other factors such as market structure and taste and preferences (Knetter and Slaughter, 2001). However, in this paper, we do not examine these factors.

The LOP is built up under perfect information and if the mechanisms work there can be trade. However, if there is imperfect information, there is uncertainty amongst traders. Trade only occurs above the threshold of uncertainty. Within a country this uncertainty comes from inflation and between countries it comes with exchange rate volatility. What inflation does domestically is that it introduces some uncertainty in  $P_j$  so that we have the following specifications. Taking the above equation, the uncertainty component is within  $P_j$  and therefore we have the following:

$$P_j = P^- + \delta$$

Where  $\delta$  is the uncertainty. On the domestic market, this uncertainty comes through inflation. The larger the variance of this uncertainty the more price dispersion we anticipate. Substitution equation 2 into equation 1 gives us the following specification:

$$P_i = (P^- + \delta) + \tau(x_1, x_2, \dots, x_n) + \mu_j$$

In this specification, we control for  $\tau(\cdot)$  with distance and then market conditions  $\mu_j$  with city and product dummies. In our framework, the variance is measured by the time trend in Zimbabwe to proxy for improving price signals. On the international market, this uncertainty comes through exchange rate volatility which distorts price signals and thus discourages trade

## **EMPIRICAL LITERATURE REVIEW**

The empirical literature on price dispersion can be divided into three sections – studies which analysed both within and between country dispersion based on disaggregated data; studies which analysed only within and between country price dispersion in the Euro Area and within and between country price dispersion in Africa.

### **Within and Between Country Price Dispersion**

Empirical literature for within and between country price dispersion has received widespread attention in recent years. Engel & Rodgers (1996) initiated the empirical work on within and between country price dispersion. They examine the nature of deviations from the law of one price using CPI data for U.S. and Canadian cities for 14 categories of consumer prices. The study finds that distance between cities explains a substantial amount of variation in the prices of comparable goods in different cities. In addition, they show that the variation is much higher for two cities located in different countries than for cities in the same country.

Parsley & Wei (2001) exploit a panel dataset of prices of 27 traded goods across 96 cities in the US and Japan. They find that crossing the US Japan border is equivalent to adding as much as 43 trillion miles to cross country volatility of prices. Like Engel & Rodgers (1996), they also find that distance and exchange rate volatility collectively explain a substantial portion of international price dispersion. Crucini et al (2003) analyse study deviations from the Law of One Price using retail prices of 220 individual goods across 122 cities located in 79 countries in the European capital cities. They find that there is greater price dispersion internationally than intranationally. Comparable to Engle & Rodgers 1996; Parsley & Wei (2001) they find that distance matters, showing that distance coefficients for both intranational and international price dispersion is not too different.

Furthermore, Chikako (2007) analyse the price difference between Japan and Korea using goods-level consumer price data. They find that the national border has a larger effect on price dispersion in both time series volatility and cross-sectional difference analysis. They however add on by categorizing goods by their perishability to analyse price dispersion. They find that price dispersion depends on the characteristics of goods since absolute purchasing power parity applied to a greater extent for durable goods.

For within country price dispersion, there are a number of studies which use panel data sets to measure price dispersion. These studies include Parsley & Wei (1996); Fan & Wei (2003);

Ceglowski (2003); Blomberg & Engel (2012). This literature examine price dispersion within the borders of a country. Parsley & Wei (1996) uses a panel of 51 prices from 48 cities in the United States to provide an upper bound estimate of the rate of convergence to purchasing power parity. They use panel unit root hypothesis to assess speed of convergence of prices. They find that convergence occurs faster for larger price differences. In addition, they concluded that the rates of convergence are slower for cities which are further away from each other.

Fan & Wei (2003) examine the law of one price for China using the same methodology used by Parsley & Wei (1996). They find strong evidence supporting long run convergence to the law of one price in China. In their comparison with developed markets, they also find that both pattern and speed of convergence is highly comparable to developed markets. Engel and Rodgers (1999) use disaggregated consumer prices data to determine why there is variability in prices of similar goods across US cities. They however use price indexes in their analysis, and find that distance between cities constitute a significant proportion of variation in prices between pair of cities. In addition, they also find that price stickiness also plays an important role in price dispersion. Like Engel & Rodgers (1999), Cechetti et al (2002) use price indices to examine price convergence for major US cities and find that relative price levels among cities mean revert at a very slow rate.

### **Within and between country price dispersion in the Euro Area**

The Euro area is a classic example of where several countries opted to introduce a common currency. Since the introduction of the Euro in 1999, several studies have attempted to measure the degree of price dispersion within and between countries in the Eurozone (see Engel & Rodgers (2004); Reiff & Rumler (2014); Goldberg & Verboven (2005); Allington *et al* (2005); Cavallo *et al* (2014); Dvir & Strasser (2014)). The general consensus in these studies is that price dispersion is lower for countries in the currency union than those outside of a currency union.

Engel & Rogers (2004) used a detailed dataset of prices of consumer goods in European cities from 1990 to 2003 to investigate whether the introduction of the Euro increased integration of consumer markets. Comparing with the results from the US and Canada, they find no evidence of prices converging between countries after the introduction of the Euro. On the contrary, they find that there has been significant reduction in price dispersion before introduction of the Euro

(in the 1990s). However, their assessment was still in the early days of the introduction of the Euro.

In a study of the European car market, Goldberg & Verboven (2005) contrasted the earlier results by Engel and Rodgers (2004). They find strong evidence of convergence towards both absolute and relative versions of the Law of One Price between European cities. Similar results were reported by Allington *et al* (2005), suggesting robustly that the Euro had a significant integrating effect. Reiff and Rumler (2014) concur with these findings, arguing that price dispersion in the Euro area has declined since the inception of the monetary union. Another important insinuation which can also be drawn from the study by Reiff and Rumler (2014) is that between country price dispersion is larger than within country price dispersion even after controlling for product heterogeneity. They argue that cities which are close to each other tend to have prices which moves closely together.

Overall, there is strong evidence that price dispersion is lower for countries in the euro zone than for countries outside the euro zone. The entry of Latvia in the Euro zone in January 2014 provides an opportunity to investigate this further. Cavallo (2014) shows that soon after Latvia's entry into the Euro zone, price dispersion immediately dropped with the percentage of prices nearly identical to those in Germany increasing from 6 percent to 89 percent.

### **Within and between Country Price Dispersion in Africa**

Empirical literature on price dispersion in Africa remains limited due to lack of disaggregated data at the consumer price level. A few studies have attempted to measure the extent of price dispersion within and between African countries (see Edwards and Rankin (2012a); Versailles (2012); Brenton *et al* (2014); Nchake (2013); Balchin (2015); Mudenda (2016). Edwards and Rankin investigate price dispersion for over 200 products in 13 African cities. They show that price dispersion at the retail level amongst the sample of African cities collapsed, with much decline concentrated on North African cities in the 1990s. The results concur with what is found in Europe and the United States.

Brenton *et al* (2014) uses monthly consumer prices for 150 towns in 13 cities in Central and Eastern Africa for three food staples-maize, rice and sorghum and demonstrates that markets are more integrated within than between countries. Similar results are reported by Nchake (2013) for Southern African Customs Union (SACU) countries, indicating that mean price

differences between countries (0.43) are larger than within the same country (0.225). Balchin (2015) concurs with the findings, showing that price dispersion is higher between Southern Africa Development Community (SADC) countries than within those individual countries.

Furthermore, these studies show that countries which are members of the same regional trade agreements have substantially thinner borders with other members (Brenton *et al*, (2014). Balchin *et al* (2015) reports similar results for the SACU countries, with Nchake (2013) reporting that the border effect in the SACU region declined substantially between 2004 and 2008.

Versailles (2012) studies border effects using consumer price data for four East African Community (EAC) member states. The study shows that the border effect, as measure by the coefficient of the border dummy in the sample countries is smaller compared to what is reported in literature by Engel and Rodgers. The paper also shows that the advent of a customs union in the East African Community in 2005 improved market integration as shown by the reduced border effect between Kenya and Uganda.

Mudenda (2016) investigates the relationship between tariff reforms and internal product market integration in Zambia, a low income country. The results from this study indicate wide product variation and imperfect transmission of changes in tariffs to domestic prices. Importantly, the study shows that pass through of tariffs to consumer prices in Zambia is strongly related to the tradability of products. Balchin *et al* (2015) for SADC countries and Versailles (2012) for the EAC concurs with this finding, arguing that there is high price dispersion between countries for food products. For developed countries, Engel (1999) and Crucini (2005) show that in theory, LOP deviations should be larger for less tradable goods and for goods that use more non-tradable inputs in production.

To conclude, existing studies in Africa on price dispersion have focussed more on stable macroeconomic environments, and some studies are limited to agricultural or narrow range of products. The only study which included Zimbabwe in the analysis was Edwards and Rankin (2012b); however, the analysis was based on volatile price data, prior to the introduction of a new currency system in Zimbabwe. This study intends to fill in this research gap, by using disaggregated data after the introduction of a new currency system to measure price dispersion within and between Zimbabwe and South Africa.

## METHODOLOGY AND DATA

### Data description

This paper utilises disaggregated retail price data collected at the provincial level in Zimbabwe and South Africa. Raw data is drawn from monthly retail prices used in the computation of the Consumer Price Index for the period February 2009 to August 2014 (68 month period). Each individual price record corresponds to a uniquely defined product sold at a particular province at a given point in time. This allows us to track the price of each individual product item overtime within the same retail outlet. Within each individual price record, there is the following information – date (month and year); retail outlet (represented by a unique number, which in terms of confidentiality purposes does not allow us to identify the outlet by its name, though we can be able to track it overtime); product (with brand names in some cases); province; unique codes and the price of that item. Table 1 presents the products used in this paper.

**Table 1: Price records by product category**

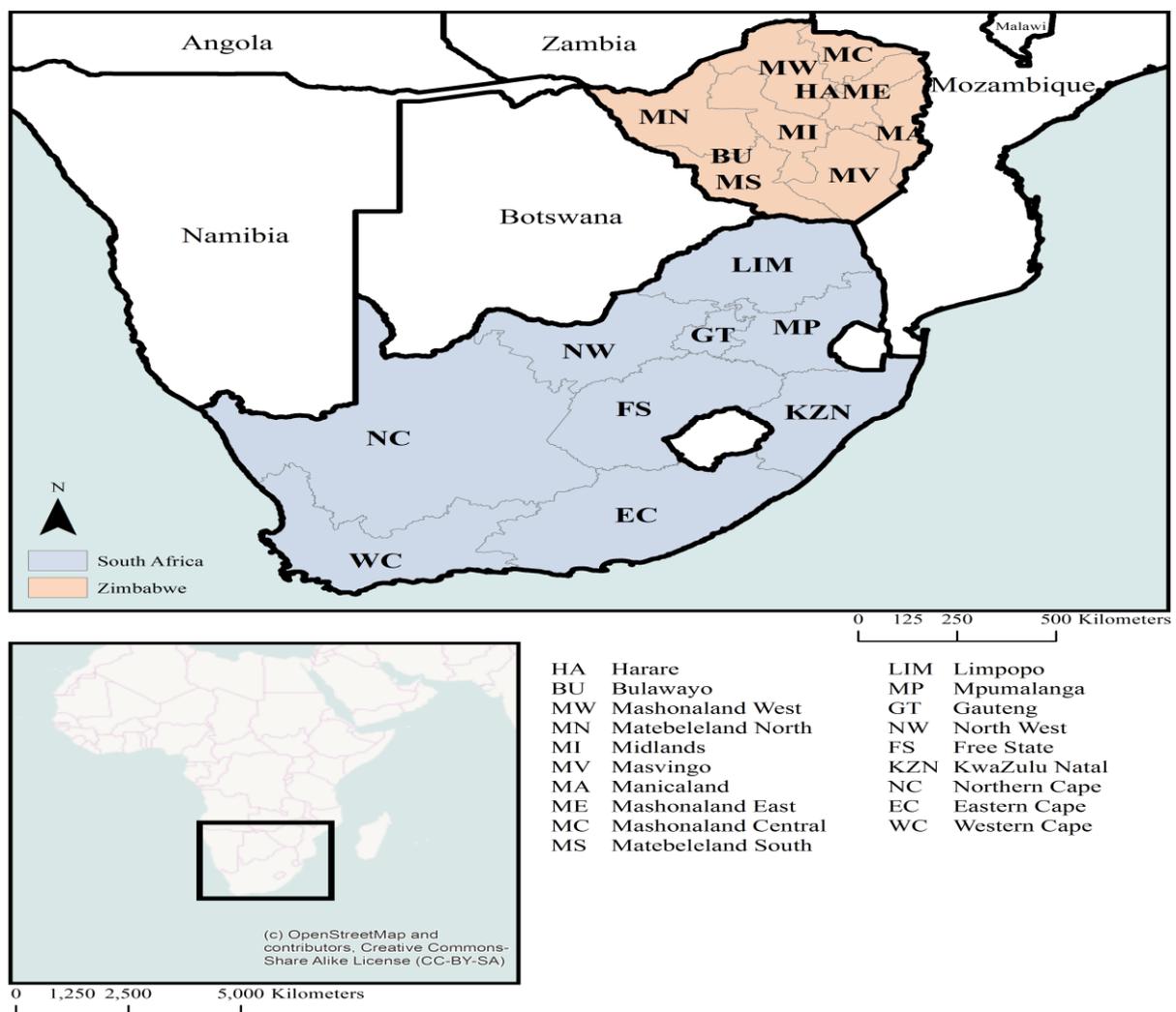
Product Category	Zimbabwe		South Africa					
	Number of price records	Percent	Number of product items	Percent	Number of Price Records	Percent	Number of Product Items	Percent
Food	415 944	38.37	117	23.78	94 155	41.45	209	27.50
Non-Alcoholic Beverages	56 310	5.19	14	2.85	14 133	6.22	25	3.29
Alcoholic Beverages, Tobacco and Narcotics	53 268	3.86	17	3.46	7 393	3.25	13	1.71
Clothing and Footwear	124 273	8.85	69	14.02	37 631	16.56	74	9.74
Housing, Water, Electricity, Gas & Other Fuels	28 214	2.6	22	4.47	6 232	2.74	17	2.24
Furniture, Equipment & Household Operations	153 243	1.77	63	12.80	26 604	11.71	57	7.50
Medical Care & Health Expenses	45 400	4.19	27	5.49	6 509	2.87	14	1.84
Transport	56 112	5.18	39	7.93	5 662	2.49	19	2.50
Communication	9 845	0.91	16	3.25	699	0.31	1	0.13
Recreation & Entertainment	19 908	1.84	57	11.59	17 477	7.69	39	5.13
Other Goods & Services	121 537	1.55	51	10.37	10 681	4.70	292	38.42
Total	1 084 054	100	492	100	227 176	100	760	100

Table 1 shows a breakdown of price records by product category. There are 1,084,054 price records for the 68 month period, with 492 product items. Product items are disaggregated into food (117 products); Clothing (56); Recreation and Entertainment (57); Household Operations (51) and other products. Food products constitute the greater number of price records, making up close to 50 percent of price records, although constituting only 23.78 percent of total products.

For South Africa, there are 227,176 price records with 760 product items. As with the Zimstat dataset, food products (41.45 percent) constitute almost close to 50 percent of all price records. Communication (0.31 percent) has the least number of price records.

These price records are then aggregated at provincial levels at the product level to calculate the geometric mean. The geometric mean for each provincial capital is then used to calculate price dispersion across city pairs. The geographical map of provinces in Zimbabwe and South Africa is shown in Figure 1.

**Figure 1: Geographical map of provinces in Zimbabwe and South Africa**



Our main aim in the study is to measure price dispersion in retail product prices within and between Zimbabwe and South Africa. To do this, we match products which are uniquely defined with the intent of comparing similar products across these two markets. The final

dataset constructed by matching similar products consists of monthly product prices for 83 narrowly defined products spanning for the period February 2009 to August 2014. Table 2 presents the matched products.

**Table 2: List of matched goods**

Rice	Cereals	Cheese	Spinach
White Bread	Beef	Ice Cream	Cabbage
Brown Bread	Pork	Sour Milk	Tomatoes
Biscuits	Chicken	Eggs	Pumpkins
Spaghetti	Boerewors	Margarine	Cucumber
Macaroni	Pork Sausage	Peanut Butter	Onions
Cake	Bacon	Bananas	Carrots
Flour	Fresh Milk	Dried Fruits	Backed Beans
Chutney	Condensed Milk	Peanuts	Tinned Peas
Mealie Meal	Yoghurt	Lettuce	Potato Crisps
Men's Casual Trousers	Teapot	Instant Coffee	Toilet Paper
Boys Shorts	Washing Powder	Fizzy Drink Can	Sanitary Pads
Boys Shirts	Pain Killers	Fizzy Drink Bottle	Skin Lotion
Men's Sports Shoes	Cough Syrup	Brandy	Toothpaste
Paint	Diesel	Whisky	White Sugar
Bedroom Suite	Colour TV	Red Wine	Brown Sugar
Floor Tiles	DVD Player	White Wine	Chocolate Bar
Refrigerator	Blank CD	Cigarettes	Sweets
Vinegar	Salt	Pencil	Freezer
Chutney	Baking Powder	Men's Underwear	Tennis Balls
Tomato Sauce	Microwave	Chutney	Men's Jeans

The final sample covers a diverse range of products which includes perishables, semi perishables, non-durable and durable goods. All 88 matched products are tradable, with most of the products are directly imported from South Africa into Zimbabwe. In addition, products which are not directly imported share similar characteristics which makes it easier to measure the extent of product market integration between the two countries. However, it is worth noting that some of the products are not perfectly homogeneous because of branding and quality of these products.

## EMPIRICAL MODEL SPECIFICATION

Following earlier work by Parsley and Wei (1996), we calculate price dispersion as the mean absolute price deviation between city pairs. Price dispersion is calculated for each city pair implying that LOP deviations between cities are calculated relative to each city pair. Price dispersion is calculated as:

$$Q_{ij,k,t} = \ln \left( \frac{P_{i,k,t}}{P_{j,k,t}} \right)$$

Where  $Q_{ij,k,t}$  is the price dispersion - the standard deviation of the percentage price difference,  $P_{i,k,t}$  is the price of commodity  $k$  in city  $i$  at time  $t$  and  $P_{j,k,t}$  is the price of commodity  $k$  in city  $j$  at time  $t$ . The mean absolute price deviation (price dispersion) is defined as the mean absolute deviation of log prices between provinces overtime shown as  $|\ln(\frac{P_{i,k,t}}{P_{j,k,t}})|$ .

To evaluate price dispersion, we first create city and time dummies. City dummies give average price dispersion over the time period. Since our data comes monthly, the interaction between city and time dummies gives price dispersion for each time period. City dummies control for local market conditions (including seasonality) represented by  $\mu_i$  in the theoretical framework. We control for these market conditions in our empirical specification. To capture the uncertainty of price signals within Zimbabwe, we create a within country dummy (Zim dummy) which takes the value of one if city pairs are in Zimbabwe and zero if city pairs are between Zimbabwe and South Africa or South Africa. In addition, we create the between country dummy (Zimbabwe-South Africa dummy) which takes the value of one if city pairs are Zimbabwe and South Africa and zero if city pairs are in Zimbabwe or South Africa only. Our empirical specification is as follows:

$$Q_{ij,t} = \delta + \beta_1 d_{j,k} + \beta_2 b_{j,k} e_{j,k} + \beta_3 w_{j,k} \gamma_t + \gamma_t + \mu_{j,k} + \varepsilon_{j,k,t}$$

Where  $d_{j,k}$  is the log of distance between city pairs. We posit a positive relationship between price dispersion and distance.  $b_{j,k}$  is a dummy variable for whether city pairs  $i$  and  $j$  are located in different countries. The dummy takes the value of one if city pairs are located between Zimbabwe and South Africa and zero when city pairs are located within the country.  $e_{j,k}$  is the exchange rate volatility which captures uncertainty between countries as shown in the theoretical framework. The interaction between the dummy variable  $b_{j,k}$  and exchange rate volatility gives us the border effect. We expect the coefficient to be positive as we hypothesized

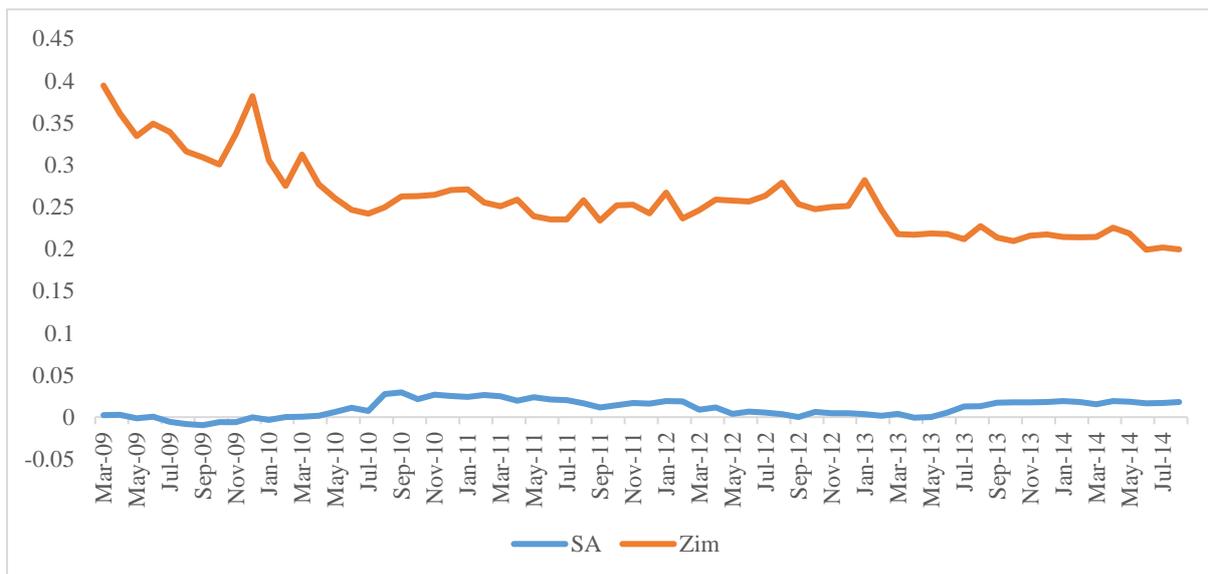
that areas which are farther apart tend to have less similar cost structures. In addition, literature in pricing to market (See Knetter and Slaughter, 2001) emphasize that market conditions (mark-up) maybe different across locations and vary with exchange rates. We also include  $w_{j,k}$ , a dummy variable which takes the value of one if city pairs are in Zimbabwe and takes zero if city pairs are Zimbabwe-South Africa or South Africa.  $\gamma_t$  is the time trend, and the interaction between  $w_{j,k}$  and  $\gamma_t$  captures the uncertainty in Zimbabwe, that is price signals after hyperinflation.  $\gamma_t$  controls for global shocks and  $\mu_{j,k}$  captures city and products fixed effects. The regression error term is denoted by  $\varepsilon_{j,k,t}$ .

## PRICE DISPERSION FOR ZIMBABWE AND SOUTH AFRICA

In this section, we focus on the matched products, all of which are traded goods. As described in our construction of the dataset, the matched products have similar characteristics and allows us to compare within and between country price dispersion. In our matching process, we attempt to limit product variations in individual goods. Price dispersion is calculated for each city pair within and between the two countries. The sample produces 171 city pairs<sup>2</sup>. Firstly, we find it useful to compare the distributions of two types-intranational Zimbabwe city pairs and intranational South Africa city pairs.

Let  $P_{i,k,t}$  is the price of commodity  $k$  in city  $i$  at time  $t$  and  $P_{j,k,t}$  is the price of commodity  $k$  in city  $j$  at time  $t$ . Price dispersion is therefore defined as the mean absolute deviation of log prices between city pairs shown as  $|\ln(\frac{P_{i,k,t}}{P_{j,k,t}})|$ . Figure 2 plots price dispersion within each of the two comparisons (within Zimbabwe and within South Africa) from February 2009 to August 2014.

**Figure 2: Price Dispersion for Zimbabwe and South Africa**



We report results for a pooled regression of all the 88 matched products overtime. Price dispersion for Zimbabwe falls sharply for the first 18 months after the introduction of a new currency system before it remains fairly stable for the remaining period whilst price dispersion for South Africa is fairly stable throughout the period. Our results also reveal volatility in prices

<sup>2</sup> 171 city pairs were based on the following calculation  $\frac{n(n+1)}{2}$  where  $n$  is the total number of cities in the sample, 10 from Zimbabwe and 9 from South Africa.

is slightly higher for cities in Zimbabwe than cities in South Africa. This leads us to our next question – did prices within Zimbabwe converged faster relative to South African prices and if so, what were the mechanisms through which the prices adjusted.

### **Within and Between Country Price Dispersion**

Figure 2 shows that price differences between Zimbabwe and South Africa narrows with time. The evidence in the previous subsection points to the fact that the violation to the law of one price after the introduction of a new currency system has a downward trend. This downward trend can come from within the country (improving price signals) or from the international market through exchange rate volatility (we already built this in the theoretical framework). We intend to investigate these factors explicitly and see how each of them impact our variable of interest which is price dispersion.

We begin by replicating the analysis of the border effect by Engel and Roger (1996) and Parsley and Wei (2001). To achieve this, create a within country dummy variable which captures within country variation in prices and a between country dummy variable which captures the border effect. In the empirical specification,  $w_{j,k}$  captures within country variation, which takes the value of one if city pairs are in Zimbabwe and takes zero if city pairs are between Zimbabwe and South Africa or in South Africa. We include  $b_{j,k}$ , which captures between country variation, a dummy variable for whether city pairs  $i$  and  $j$  are located in different countries. The dummy takes the value of one if city pairs are located between Zimbabwe and South Africa and zero when city pairs are located within the country. We interact both the two dummy variables with the time trend to get the price difference at each point in time after controlling for product and city dummies. Specifically, we regress the price dispersion  $Q_{ij,t}$  on the within Zimbabwe dummy and the border dummy variable.

$$Q_{ij,t} = \delta + \beta_1 w_{i,j} \gamma_t + \beta_2 b_{i,j} \gamma_t + \gamma_t + \mu_{j,k} + \varepsilon_{jk,t}$$

Where  $w_{i,j}$  is a within Zimbabwe dummy,  $b_{i,j}$  is a between country dummy and  $\gamma_t$  is the time trend.  $\mu_{j,k}$  captures the within city pairs variation and within product variation. Table 3 presents estimates of a pooled regression results of the interaction between the trend and the square of the trend with the Zimbabwe dummy and the border dummy with heteroscedasticity-consistent standard errors below the estimates.

**Table 3: Explaining within country and between country variation in prices**

VARIABLES	(1)	(2)
Zimbabwe	0.167*** (0.00624)	0.198*** (0.00662)
Trend	5.79e-06*** (1.20e-06)	2.41e-05*** (4.67e-06)
Zimbabwe x Trend	-6.67e-05*** (1.64e-06)	-0.000156*** (6.65e-06)
Trend Squared		-9.15e-09*** (2.26e-09)
Trend x Border	-2.92e-05*** (1.45e-06)	4.30e-08*** (3.14e-09)
Border	0.302*** (0.00655)	0.326*** (0.00681)
Zimbabwe x Trend Squared		-0.000100*** (5.76e-06)
Border x Trend Squared		3.46e-08*** (2.76e-09)
Constant	0.178*** (0.00445)	0.172*** (0.00469)
City Effects	Yes	Yes
Observations	742,474	742,474
R-squared	0.157	0.158
Number of Joint Commodity	88	88
N	742474	742474

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Specification 1 presents results from a linear trend. Both variables (Zimbabwe dummy, trend and the interaction between the Zimbabwe dummy and the trend) in the first specification are statistically significant. The negative coefficient of the interaction between the Zimbabwe dummy and the trend implies that prices in Zimbabwe have been declining overtime by 0.24 percent per year<sup>3</sup>. We do the same analysis for the border effect. The negative coefficient of the interaction of trend and border also shows that prices between Zimbabwe and South Africa have been declining by 0.10 percent per year. From our coefficient estimates, prices within Zimbabwe converged faster relative to South African prices than prices between Zimbabwe and South Africa. This can be shown by plotting the coefficients of the regression.

In order to get a clear picture of the fall in price dispersion within and between Zimbabwe and South Africa, we also interact the within Zimbabwe dummy with a quadratic function of the square of trend variable. The results are shown in equation 2 of Table 3. We multiply the coefficients of trend and the square of the trend variable by time in days. The South Africa

<sup>3</sup> Figure 3 plots the fall in price dispersion in Zimbabwe yearly, the fall in the border effect and price dispersion in South Africa

prices are at levels. To get the within Zimbabwe price dispersion, we add on the Zimbabwe dummy to the product of the coefficient of trend and trend squared variable. We also add the product of the interaction of trend and the Zimbabwe dummy variable to the specification to obtain how prices have been falling overtime in Zimbabwe. We repeat the same analysis for the border effect and plot both the linear and quadratic functions to show how prices have been falling overtime in Zimbabwe. Figure 3 presents price dispersion overtime.

**Figure 3: Price dispersion and time**

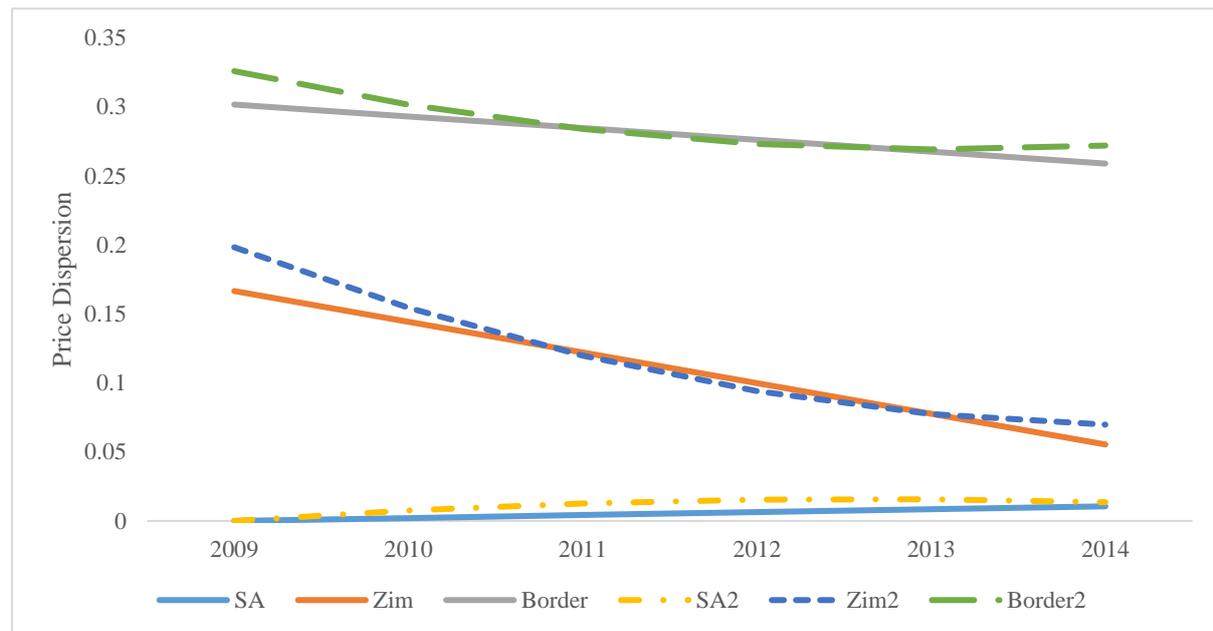


Figure 3 presents results and corroborates with our findings that price dispersion has been falling overtime both within Zimbabwe and between Zimbabwe and South Africa. The dotted lines shows the square of the trend. Price dispersion initially falls rapidly immediately after the introduction of a new currency system and then gradually falls at a decreasing rate as the country moves further away from the date the new currency system was introduced. Price differences for South Africa has been gradually increasing overtime as shown by the yellow dotted line.

Our results corroborate with international literature - Parsley and Wei (2001) show that for Japan and the US, there has been a statistically significant trend decline in relative price variability for both within and between countries. Although the coefficient of interaction of the trend and the border dummy is negative, the within Zimbabwe dummy is much stronger, implying that price became more integrated within Zimbabwe than between Zimbabwe and South Africa.

## **ROLE OF EXCHANGE RATE VOLATILITY**

In our theoretical framework, we argue that uncertainty on the domestic market comes from inflation and uncertainty on the international market comes from exchange rate volatility. This uncertainty causes the domestic prices of goods to deviate from the foreign prices. The larger this uncertainty, the more price dispersion we anticipate. Empirical literature on pricing to market argue that cities that lies across national borders may have huge price differences due to mark up and exchange rate changes (Engel & Rogers, 1996). Parsley and Wei (2001) show that exchange rate volatility is positively related to cross country price dispersion for the US and Canada. This uncertainty, when applied to developing countries can be huge since there is too much volatility in currencies.

In this paper, we assess the impact of exchange rate volatility on both within and between country price dispersion. Exchange rate volatility is defined as the standard deviation of the log of changes in exchange rates. We obtain daily exchange rates from the South African Reserve Bank (SARB) and calculate the standard deviations for each month. We lag the standard deviation of exchange rates over a twelve (12) month period and regress it against the price dispersion as shown in Table 4.

We run four different equations to assess the impact of exchange rate volatility on both within country and between country price dispersion. We present results with the standard deviation of exchange rates lagged only for one month. Other monthly lags are reported in Table 7 in the appendix. Specification 2 tests for the impact of the first lag of exchange rate volatility. Specification 3 interacts the within country and the between country dummy with exchange rate volatility. This specification gives us the average impact of exchange rate volatility on within and between country price dispersion. Specification 4 is interesting because it gives the impact of exchange rate volatility on price dispersion at each point in time. We report heteroscedasticity-consistent standard errors in parentheses.

**Table 4: Exchange rate volatility and price dispersion**

VARIABLES	(1)	(2)	(3)	(4)
Zimbabwe	0.167*** (0.00624)	0.167*** (0.00624)	0.153*** (0.00659)	0.117*** (0.00734)
Trend	5.79e-06*** (1.20e-06)	6.95e-06*** (1.20e-06)	5.17e-06*** (1.22e-06)	1.72e-06 (2.60e-06)
Zimbabwe X Trend	-6.67e-05*** (1.64e-06)	-6.71e-05*** (1.65e-06)	-6.50e-05*** (1.67e-06)	-3.13e-05*** (3.58e-06)
Border X Trend	-2.92e-05*** (1.45e-06)	-2.94e-05*** (1.45e-06)	-2.71e-05*** (1.48e-06)	-2.39e-06 (3.16e-06)
Border	0.302*** (0.00655)	0.302*** (0.00655)	0.287*** (0.00682)	0.261*** (0.00735)
Exchange Rate Volatility <sub>t-1</sub>		0.0464*** (0.00485)	-0.0251** (0.00991)	-0.0466*** (0.0174)
Zimbabwe X Average Exchange Rate Volatility <sub>t-1</sub>			0.0882*** (0.0137)	0.342*** (0.0259)
Border X Average Exchange Rate Volatility <sub>t-1</sub>			0.0970*** (0.0121)	0.270*** (0.0218)
Exchange Rate Volatility <sub>t-1</sub> X Trend				2.42e-05 (1.61e-05)
Zimbabwe X Exchange Rate Volatility <sub>t-1</sub>				-0.000247*** (2.27e-05)
Border X Exchange Rate Volatility <sub>t-1</sub>				-0.000177*** (1.97e-05)
Constant	0.178*** (0.00445)	0.171*** (0.00452)	0.182*** (0.00473)	0.185*** (0.00521)
City Effects	Yes	Yes	Yes	Yes
Observations	742,474	742,474	742,474	742,474
R-squared	0.157	0.158	0.158	0.158
Number of Joint Commodity	88	88	88	88
N	742474	742474	742474	742474

Standard errors in parentheses  
\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regression results indicate that higher exchange rate volatility leads to higher price dispersion. Specification 2 controls for exchange rate volatility and the coefficient sign is positive and statistically significant. This concurs with results from earlier work by Parsley and Wei (2001) for the US and Canada. Specification 3 further strengthens our results with the impact being stronger for between country price dispersion than within country. More importantly, the coefficient of the border dummy declines from 0.302 percentage points to 0.287 percentage

points if we interact exchange rate volatility with the within and between country dummy. Specification 4 is more interesting as it gives the impact of exchange rate volatility at each point in time. We find that the impact of exchange rate volatility on within price dispersion has fallen with time (for a year, the impact fell by approximately 0.09 percentage points). However, the impact for between country price dispersion is lower than that of within Zimbabwe price dispersion. In general, exchange rate volatility has an important impact on price dispersion although the impact is greater within Zimbabwe than between Zimbabwe and South Africa. Also note that the coefficient of the border effect reduces when we control for exchange rate volatility.

## **ROLE OF TRADE IN PRICE DISPERSION**

The analysis thus far shows that the border effect has been changing and falling with time. In our analysis, we attributed part of the fall to uncertainty (domestic market conditions on the local markets and exchange rate volatility on the international market). We show that exchange rate volatility has a significant effect and positive effect on price dispersion within and between countries. However, it does not fully account for the border effect. Empirical literature spearheaded by Paul Krugman (1991) suggests that much of the pattern of international trade can be explained by geographical considerations (distance), which brings us to the role of trade in price dispersion.

To investigate the role of trade in price dispersion, we first specifically control for trade in the specific product. Our objective is to isolate how much of the price dispersion can be attributed to trade. Trade data is obtained at the product level, downloaded from the World Integrated Trade System (WITS) of the World Bank. We used the lagged value total imports of Zimbabwe from South Africa for the matched commodities at the product level<sup>4</sup>.

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<sup>4</sup> Imports are downloaded from the Wits website. Since some products have ambiguous definitions, we narrow down our set of products to 32. Consequently, since our price data comes monthly, we take the price of June for each year as our reference price for that particular year.

**Table 5: Price Dispersion and Trade**

VARIABLES	(1)	(2)
Zimbabwe	0.116*** (0.0275)	0.124*** (0.0275)
Imports	-4.09e-07*** (1.48e-07)	8.98e-07*** (1.86e-07)
Zimbabwe X Imports		-7.54e-07*** (1.86e-07)
Border	0.334*** (0.0288)	0.354*** (0.0287)
Border X Imports		-2.19e-06*** (1.60e-07)
Year 2010	-0.0634*** (0.00565)	-0.0627*** (0.00563)
Year 2011	-0.0464*** (0.00568)	-0.0458*** (0.00566)
Year 2012	-0.0371*** (0.00566)	-0.0365*** (0.00564)
Year 2013	-0.0473*** (0.00549)	-0.0472*** (0.00547)
Year 2014	-0.0612*** (0.00554)	-0.0610*** (0.00552)
Constant	0.180*** (0.0203)	0.167*** (0.0203)
Observations	26,798	26,798
R-squared	0.207	0.214
Number of Joint Commodity	32	32
N	26798	26798

Standard errors in parentheses  
\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 5 presents the role of trade on price dispersion within and between countries with heteroscedasticity consistent standard errors reported in parenthesis. The results after controlling for imports are reported in specification one. We show that imports are significant and negatively related to price dispersion. This means that the more imports from South Africa into Zimbabwe the lower the prices are dispersed within and between countries. The coefficient of the border dummy is positive and significant.

Regression results when we interact the within country and border dummy are reported in specification two of Table 5. This specification is interesting because it allows us to split the impact of imports on price dispersion. For both within and between country price dispersion, the coefficients are negative and significant implying that higher import entails lower price dispersion relative to South African prices. We control for yearly dummies in both specifications and our results are virtually unchanged. There was a huge impact in price

dispersion in 2010 but the yearly dummies were fairly constant throughout the study period. Our only explanation with regards to the pooled regression is that trade explain some of the variation in prices but does not change the yearly dummies by very much. This means that there something in hidden in the yearly dummies that explains this variation in prices. We try to look into the tradability of products in the next section to examine where most of this dispersion comes from.

## **COMPARISON OF PRICE DISPERSION ACROSS PRODUCTS**

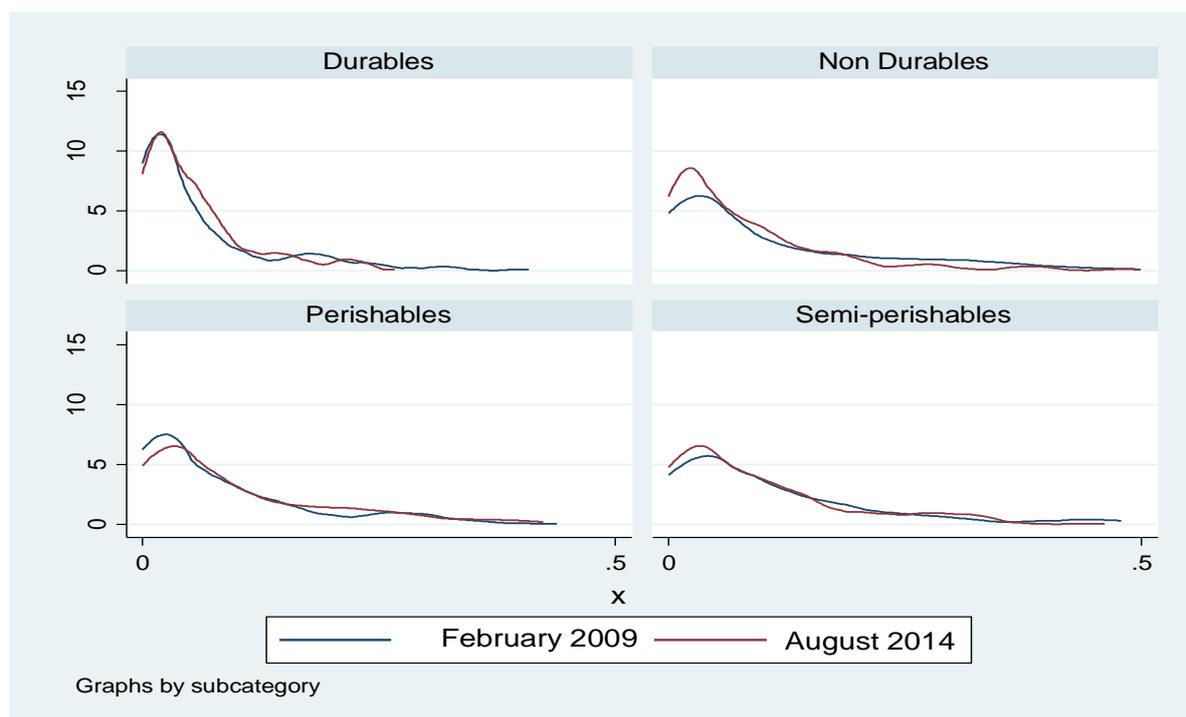
The above analysis focused on price dispersion computed as averages for a pooled set of products. Our next step is to do the same analysis at the product level. It is important to note that price dispersion at the product level allows us to unpack important differences across different product categories. Engel (1999) show that deviations from the law of one price are larger for less tradable goods and goods that use more non-tradable inputs in the production process. Firstly, we analyse price dispersion across different product categories by classifying them according to different product categories. We follow the same approach used by Baba (2007) to categorise products based on their perishability. Baba (2007b) argues that perishability of products stimulate arbitrage because of higher storage and transaction costs. Following this classification, products are classified into four groups – perishables; semi-perishables; non-durable; durable goods<sup>5</sup>. Price dispersion is then calculated at the category level across all city pairs.

Figure 7 plots kernel density estimates of price dispersion across different product categories. We show that perishables have a lot of variation in prices as compared to other different product categories as shown by flatter tails of the curves. Durable goods, on the contrary have steeper tails showing less price variation.

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<sup>5</sup> Baba (2007) classified perishables as those products within 5 days of expiration; semi-perishables as products within 3 months of expiration; non-durables as those products which last more than 3 months foods and non-durable household products and durables as durable household products. This approach is used to classify products in our data.

**Figure 4: Price dispersion across different product categories**



The notion behind higher price variations for perishable products is that one needs to be sure that they are going to trade on a different location. This uncertainty pushes up prices, together with high transport and storage costs leading to more price dispersion. In our theoretical framework, the higher this uncertainty, the more the price dispersion. This implies that, the tradability of products matter also for the integration of a country's product markets. Perishables products pushes the variance of uncertainty up, as in our theoretical framework thereby leading to more price volatility.

Table 4 further corroborates our findings that tradability of products matter. Results are reported with heteroscedasticity-consistent standard errors in parentheses. We have to note that we classify the tradability of products by perishability in this paper following Baba (2007a). The coefficient of the interaction of trend variable with the Zimbabwe dummy and the border effect (which are both linear in this case) are negative and statistically significant for all product categories. The coefficient of the border dummy and the within Zimbabwe dummy is also statistically significant and positive

**Table 6: Border effect across different categories**

VARIABLES	(1) Perishables	(2) Semi- perishables	(3) Non- Durables	(4) Durables
Zimbabwe	0.322*** (0.0116)	0.0498*** (0.0167)	0.137*** (0.00984)	0.200*** (0.0177)
Trend	2.61e-05*** (2.29e-06)	8.08e-07 (3.13e-06)	5.81e-06*** (1.89e-06)	-2.08e-05*** (3.15e-06)
Zimbabwe x Trend	-8.84e-05*** (3.04e-06)	-7.95e-05*** (4.34e-06)	-5.34e-05*** (2.57e-06)	-8.04e-05*** (4.90e-06)
Border	0.373*** (0.0123)	0.265*** (0.0175)	0.345*** (0.0103)	0.235*** (0.0191)
Border x Trend	-4.35e-05*** (2.72e-06)	-5.88e-06 (3.80e-06)	-4.10e-05*** (2.29e-06)	3.23e-05*** (3.98e-06)
City Effects	Yes	Yes	Yes	Yes
Constant	0.0727*** (0.00856)	0.252*** (0.0119)	0.153*** (0.00700)	0.299*** (0.0118)
Observations	174,258	115,553	301,204	109,834
R-squared	0.188	0.184	0.187	0.122
Number of Joint Commodity	20	14	34	13
N	174258	115553	301204	109834

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 4 shows that price dispersion fell overtime within Zimbabwe than between Zimbabwe and South Africa. The largest coefficient of the interaction of trend and Zimbabwe dummy is on perishable products (0.32 percent) and the smallest is on non-durable products (0.19 percent)<sup>6</sup>. For the border, the negative coefficient is high on perishable products (0.15 percent) compared to other product categories (non-durables-0.14 percent, semi-perishables-0.02 percent and durables-0.12 percent). Versailles (2012) and Balchin (2015) supports this argument and reports relatively high levels of price dispersion for perishable products for within and between countries in the East African Community and SADC region respectively. Balchin (2015) argues that these products are subject to fast deterioration and high transportation costs making them less tradable.

<sup>6</sup> Note that the coefficients above are in days. To get the yearly percentage fall, we multiply by 365 days.

## CONCLUSION

This paper examine how the introduction of a new currency system, after a period of high inflation, affect product market integration within a country. We show that price dispersion dropped sharply for the first 18 months after the introduction of a new currency system. Little convergence occurs thereafter, indicating closer product market integration within Zimbabwe. Furthermore, our results suggest that prices in Zimbabwe converged towards South African prices for the period under study.

We assess the impact of exchange rate volatility on both within and between country price dispersion. Our results indicate that higher exchange rate volatility leads to higher price dispersion. We argue that exchange rate volatility has an important impact on price dispersion but does not fully explain the border effect, rather having a greater impact within Zimbabwean prices than across borders.

We extend our analysis by assessing the role of trade in price dispersion with the objective of isolating how much of price dispersion is attributed to trade. We show that trade (proxied by the lagged value of imports) has a significant and negative effect on price dispersion. The higher the imports the lower the prices are dispersed within and between countries. When we control for yearly dummies in both our specifications, we find that there is a huge bump in the beginning of the study period but then it remains fairly constant indicating that there is something hidden in yearly dummies that explains price dispersion.

We turn next to breaking up the price dispersion into different product categories, to examine where most off this dispersion comes from. We find strong evidence that tradability of products matter. Retail prices differ most for perishable and non-durable products because of the uncertainty which come with selling these products. Overall, we find strong evidence that introducing a new currency (currency effect) which is stable improves price signals and leads to product market integration within and between countries.

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## APPENDIX

**Table 7: Price dispersion and exchange rate volatility**

VARIABLES	(1)	(2)
Zimbabwe	0.167*** (0.00624)	0.170*** (0.00623)
Trend	5.79e-06*** (1.20e-06)	1.37e-05*** (1.26e-06)
Zimbabwe X Trend	-6.67e-05*** (1.64e-06)	-6.96e-05*** (1.65e-06)
Border	0.302*** (0.00655)	0.304*** (0.00654)
Border X Trend	-2.92e-05*** (1.45e-06)	-3.09e-05*** (1.45e-06)
Exchange Rate Volatility <sub>t-1</sub>		0.0165*** (0.00526)
Exchange Rate Volatility <sub>t-2</sub>		0.0179*** (0.00527)
Exchange Rate Volatility <sub>t-3</sub>		0.0140*** (0.00522)
Exchange Rate Volatility <sub>t-4</sub>		0.0591*** (0.00341)
Exchange Rate Volatility <sub>t-5</sub>		0.0423*** (0.00317)
Exchange Rate Volatility <sub>t-6</sub>		0.00163 (0.00321)
Exchange Rate Volatility <sub>t-7</sub>		-0.0129*** (0.00317)
Exchange Rate Volatility <sub>t-8</sub>		0.0128*** (0.00317)
Exchange Rate Volatility <sub>t-9</sub>		-0.000291 (0.00309)
Exchange Rate Volatility <sub>t-10</sub>		-0.0160*** (0.00306)
Exchange Rate Volatility <sub>t-11</sub>		0.00743** (0.00300)
Exchange Rate Volatility <sub>t-12</sub>		0.00352 (0.00297)
Constant	0.178*** (0.00445)	0.148*** (0.00476)
Observations	742,474	742,474
R-squared	0.158	0.159
Number of Joint Commodity	88	88
N	742474	742474

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## ROBUSTNESS CHECKS

### Price dispersion within Harare

In the regressions so far, we used city pairs in our calculation of price dispersion within and between Zimbabwe and South Africa. This potentially leads to correlations with the distance variable and underestimates the impact of distance on price dispersion. In this section, instead of calculating price dispersion across city pairs, we use the arithmetic mean for retail outlets within the Harare Metropolitan Province<sup>7</sup>. We use data acquired from the National Incomes and Pricing Commission (NIPC) in Zimbabwe<sup>8</sup>. Raw data is collected weekly and comes in excel files. Data is then converted into monthly price records by taking the middle of the month price as the reference price for that particular month and the data is available from January 2012. The data covers approximately 31 percent of products in the CPI basket. This approach has been used by Cecchetti *etal* (2002) and O'Connell and Wei (2002). Price variation is calculated as follows:

$$P_{ijt} = \ln\left(\frac{g_{ijt}}{\bar{g}_{jt}}\right)$$

Where  $g_{ijt}$  denotes the raw price of product  $j$  in outlet  $i$  at time  $t$ , and  $\bar{g}_{jt}$  denoted the geometric mean price in the Harare Metropolitan Province. We calculate price dispersion as the mean absolute price differential. We do the same calculations using the Zimstat dataset for Zimbabwe and plot price deviations from the geometric mean as shown in Figure 5.

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<sup>7</sup> We chose Harare because it is the capital city of Zimbabwe and the behaviour of prices in Harare greatly mirrors that of Zimbabwe as a whole and lastly data for within city price variation was only available for Harare. Thirdly, we have a different dataset which includes prices in different retail outlets within Harare.

<sup>8</sup> The National Incomes and Pricing Commission only collects price data for the Harare Metropolitan province.

**Figure 5: Price Dispersion Zimbabwe and Within Harare**

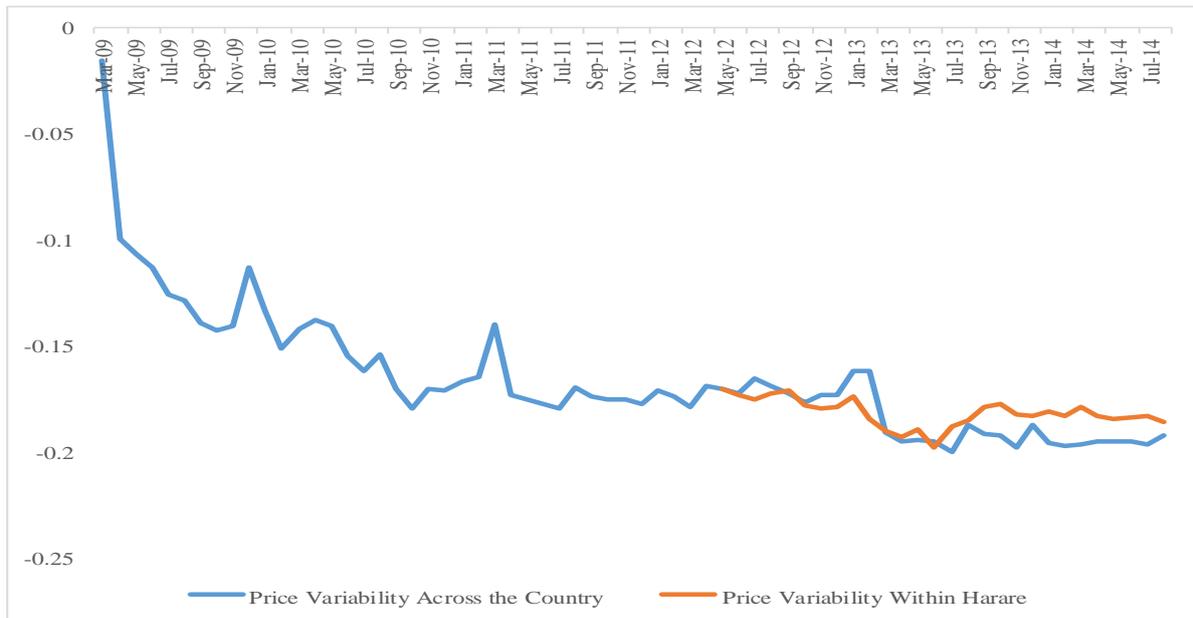


Figure 5 plots price dispersion across different provinces in Zimbabwe and price dispersion within retail outlets in Harare. Due to data limitations, prices for retail outlets within Harare only start from January 2012 to August 2014 with data for all the outlets across the country starting from March 2009 to August 2014. Price dispersion for within Harare co-moves together with price dispersion for all products in Zimbabwe. There is a huge fall in price dispersion at the beginning of the 2009. This corroborates with our earlier findings using city pairs data.

This section measure price dispersion within Zimbabwe using Harare and the natural benchmark. We show that price dispersion across different provinces in Zimbabwe sharply dropped soon after the introduction of a new currency system. The fall was observed within tradable goods compared to non-tradable which were fairly constant throughout the study period. We show that distance is positively related to price dispersion, with locations closer to Harare having a lower predicted price dispersion compared to locations which are farther away from Harare. Conclusively, there is evidence that prices across different provinces in Zimbabwe converged towards Harare prices with time.