



# Through the Pass-Through: Measuring Central Bank Credibility

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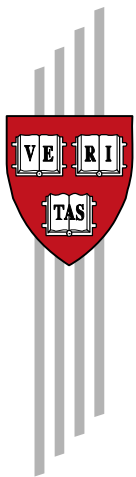
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# **Through the Pass-Through: Measuring Central Bank Credibility**

Roberto Rigobon

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## **Through the Pass-Through: Measuring Central Bank Credibility**

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**Abstract:** In the last decade, the South African Reserve Bank has been carrying out an aggressive inflation targeting program. Judging by the decline in inflation, it could be argued that the central bank has been successful in controlling the inflation rate. However, "judging by the outcomes" is not necessarily the correct measure of how much credibility has been gained in this process. In fact, part of the decline in inflation could be the result of a reduction of inflation in the world, and not necessarily to good internal policy. In this short note, I evaluate how much credibility the central bank has gained in the last three years by using a unique data set that looks at firms' decisions that are affected by the prospects of inflation. By using this measure I argue that indeed the Central Bank has gained significant credibility in recent years.

**Keywords:** South Africa, Pass-Through, Central Bank Credibility

**JEL Codes:** E52, E58

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# Through the Pass-Through: Measuring Central Bank Credibility.

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March 27, 2007

## 1 Introduction

In the last decade, the Reserve Bank of South Africa has been carrying out an aggressive inflation targeting program. Judging by the decline in inflation, it could be argued that the central bank has been successful in controlling the inflation rate. However, "judging by the outcomes" is not necessarily the correct measure of how much credibility has been gained in this process. In fact, part of the decline in inflation could be the result of a reduction of inflation in the world, and not necessarily to good internal policy. In this short note, I evaluate how much credibility the central bank has gained in the last three years by using a unique data set that looks at firms decisions that are affected by the prospects of inflation. By using this measure I argue that indeed the Central Bank has gained significant credibility in recent years.

The data I have access to is the data that Statistics South Africa uses to construct the PPI and the CPI. This is monthly data for approximately 5000 items in total. The item's descriptions are relatively detailed: For example, Wheat Bread, 500gr. In this data there is significant stickiness in prices, and what is more important, most of the items are traded. How do the data help measure the degree of credibility of a Central Bank? First, it is important to highlight that credibility has many dimensions. In this paper, with this data, I can evaluate how credible the Central Bank is to nominal shocks. In other words, how

credible the target (of inflation) is to shocks to the nominal exchange rate. Second, this can be evaluated by observing how firms set prices in response to exchange rate movements and in anticipation to future inflation expectations.

The idea is the following: assume that a particular item has a desired pass-through of  $\rho$ ; where  $\rho$  is in general less than one (the reasons of which will become clear later), and assume that it has a pass-through of domestic inflation of  $\theta$ . In principle,  $\rho$  and  $\theta$  might be different or the same.

A credible central bank that announces a inflation target of  $\pi$  is 100 percent credible if in the presence of a transitory exchange rate shock, the target is unaffected - and therefore the central bank is able to keep it. On the other hand, a non-credible central bank implies that a nominal exchange rate devaluation will be *accommodated* by the central bank with further domestic inflation. This is the definition of credibility I use in this paper: how much of the nominal exchange rate movements are ultimately accommodated by the monetary authority. In the case of a credible Central Bank, the pass through of exchange rate movements is only  $\rho$ , while in the case of a non-credible central bank the pass-through is  $\rho + \theta$  (assuming that all the devaluation is translated into domestic inflation). So, by looking at the change in the pass-through we are able to detect the gains in credibility.

Of course, the data is more complicated than this simple example. First, different items have different degrees of pass-through (hence  $\rho$  is different for each item). Second, the pass-through in the world has been coming down in all countries as reported by Campa and Golberg (2005) and Gopinath, Itskhoki, and Rigobon (2007) among many other papers. Third, other things in the economy might have changed that are also associated with a decline in the pass-through. The empirical section of the paper will try to solve part of these issues. Not everything will be solved to full satisfaction, however, the patterns I find in the data are hard to reconcile with alternative hypothesis. Hence, I conclude that the large reduction in the pass-through experienced in South Africa is the outcome of a large gain in the inflation targeting regime's credibility.

## 2 Pricing Model and Pass-Through

This section follows very closely Gopinath, Itskhoki, and Rigobon (2007).

In this section, I first describe the reasons why pass-through are less than one from exchange rates to prices, and conjecture that the same mechanisms are at work for domestic inflation and prices. Second, I summarize the regression that has to be estimated when prices are sticky. Lastly, I discuss what are the implications for central bank credibility regarding exchange rate shocks.

### 2.1 Optimal pass-through

The firm's desired price can be represented as a mark-up over its marginal cost. In particular, the desired price of any firms that has some imported and domestic inputs is:<sup>1</sup>

$$P(j; z) = \frac{\sigma(j; z)}{\sigma(j; z) - 1} \cdot \left[ (\mathcal{E} \cdot MC^*(j; z))^\theta (MC(j; z))^{1-\theta} \right], \quad (1)$$

where  $\sigma(j; z)$  is the effective elasticity of the firm's demand,  $MC^*(j; z)$  is the cost of imported inputs,  $MC(j; z)$  is the cost of the domestically produced inputs,  $\theta$  is the proportion of foreign inputs, and  $\mathcal{E}$  is the nominal exchange rate.

Notation wise, all the nominal variables in the foreign currency are starred and  $(j; z)$  is the firm-sector identifier, i.e. it stands for firm  $j$  in sector  $z$ . Nominal exchange rate is defined as the amount of home currency per one unit of foreign currency, which means that an increase in  $\mathcal{E}$  corresponds to an appreciation in the foreign currency. The elasticity of demand is defined in a standard way as

$$\sigma(j; z) \equiv - \frac{d \ln C(j; z)}{d \ln P(j; z)},$$

where  $C(j; z)$  is the demand for the product of the firm. Define  $\mu = \ln\left(\frac{\sigma(j; z)}{\sigma(j; z) - 1}\right)$ . Writing

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<sup>1</sup>This expression comes from a standard optimality condition for the static price setting.

the prices in logs we have (variables in logs are in lower case)

$$p(j; z) = \mu(j; z) + \theta (e + mc^*(j; z)) + (1 - \theta) mc(j; z)$$

Assume that the shocks to the exchange rate, and the two marginal costs are all independent. In that setup, define the exchange rate pass-through into the desired price as the elasticity of the desired price of the firm to the changes in the exchange rate:

$$\Psi_e \equiv \frac{dp}{de} = \frac{\theta + \theta \frac{dmc^*}{de} + (1 - \theta) \frac{dmc}{de}}{1 - \left[ \frac{d\mu}{dp} + \theta \frac{dmc^*}{dp} + (1 - \theta) \frac{dmc}{dp} \right]} > 0.$$

which is always positive and less than one because all the partial elasticities are positive.

Similarly, the pass through of domestic inflation into prices is (denote the overall domestic price level as  $\pi$ )

$$\Psi_\pi \equiv \frac{dp}{d\pi} = \frac{\frac{d\mu}{d\pi} + \theta \frac{dmc^*}{d\pi} + (1 - \theta) \frac{dmc}{d\pi}}{1 - \left[ \frac{d\mu}{dp} + \theta \frac{dmc^*}{dp} + (1 - \theta) \frac{dmc}{dp} \right]} > 0.$$

In a small country, for example,  $\frac{dmc^*}{d\pi}$  is zero because domestic inflation is unlikely to affect the international price of inputs.

These derivatives summarize the theories that explain incomplete pass-through. Variable markups ( $\frac{d\mu}{dp}$ ), variable marginal costs ( $\frac{dmc}{dp}$ ,  $\frac{dmc^*}{dp}$ ), different exchange rate pass-through to inputs ( $\frac{dmc}{de}$ ,  $\frac{dmc^*}{de}$ ), and firms difference regarding imported inputs in the production function ( $\theta$ ). For all these reasons, pass-throughs are likely to be less than one, and more importantly they are likely to be different for domestic and foreign inflation.

## 2.2 Credibility and Pass-Through

One important difference between a credible and a non-credible central bank is the extent in which nominal shocks are accommodated by the monetary authority. In other words, a transitory shock to the nominal exchange rate due to agents speculation should have a small effect in domestic prices when the central bank is credible. However, that effect should be bigger if the central bank intervenes to accommodate the exchange rate movement.

What this means in practice is that the pass-through from exchange rates to prices is a combination of the two pass-throughs:  $\Psi_e + \tau\Psi_\pi$  where  $\tau$  is the expected inflation caused by the depreciation of the exchange rate ( $\frac{d\pi}{de}$ ). For the exact same economy, a credible central bank has a small  $\frac{d\pi}{de}$ , while a non credible central bank has a large  $\frac{d\pi}{de}$ .

This is the basis of the empirical evidence I am trying to find in this paper. The simplest solution would be to run a regression item by item. The problem is that because prices are sticky, the regression has to be estimated conditional on prices moving. See Gopinath, Itskhoki, and Rigobon (2007) for a detail description of the empirical specification that has to be used.

### 3 Results

I estimate several regressions of pass-through. The first one construct aggregate price indexes using the CPI and PPI data. I also construct CPI and PPI indexes per sectors and run similar regressions. The purpose of those regressions is to highlight the drop in pass-through that takes place at the aggregate level.

In the second regression I estimate item-by-item and compute the average pass-through in the economy by averaging out the individual estimates. These are the proper regressions because they take into account item heterogeneity, price stickiness, etc. Hence, even though both regressions provide the exact same message, I place a higher weight on the second approach.

#### 3.1 Aggregate regressions

In this section I construct price indexes using the micro data. To construct the aggregate price change I simply average the individual price changes.

Obviously this is a tremendous simplification because I am not taking into account the weights the items have in the consumption basket. Although this might seem as a big drawback, in practice, it is not. In my paper with Gita Gopinath (Sticky Borders) we compute all the statistics weighted and unweighted and they are almost identical. We computed that



in the imported price data of the US that has more than 100 thousand items in total. I do not have the weights, so, in this case I can do very little.

I run a simple rolling regression

$$\Delta\Pi_t = \alpha + \sum_{j=0}^{24} \beta_j \Delta e_{t+j} + \varepsilon_t$$

where the left hand side is the change in the aggregate price level, and the right hand side is the change in the Rand. On the right hand side I computed the change of the weighted exchange rate. I run robustness checks only including the real exchange rate, or the bilateral exchange rate between Rand and Euro and the results are virtually identical.

I estimate this rolling regression and compute the pass through as  $\sum_{j=0}^{24} \beta_j$ . In Figure 3.1, I depict the estimates for the CPI and the PPI where the estimate of the pass through in the first period is normalized to be zero. In other words, here I am showing the drop in the pass-through.

As can be seen, the drop in the pass-through is massive. Table 1 presents the estimates.

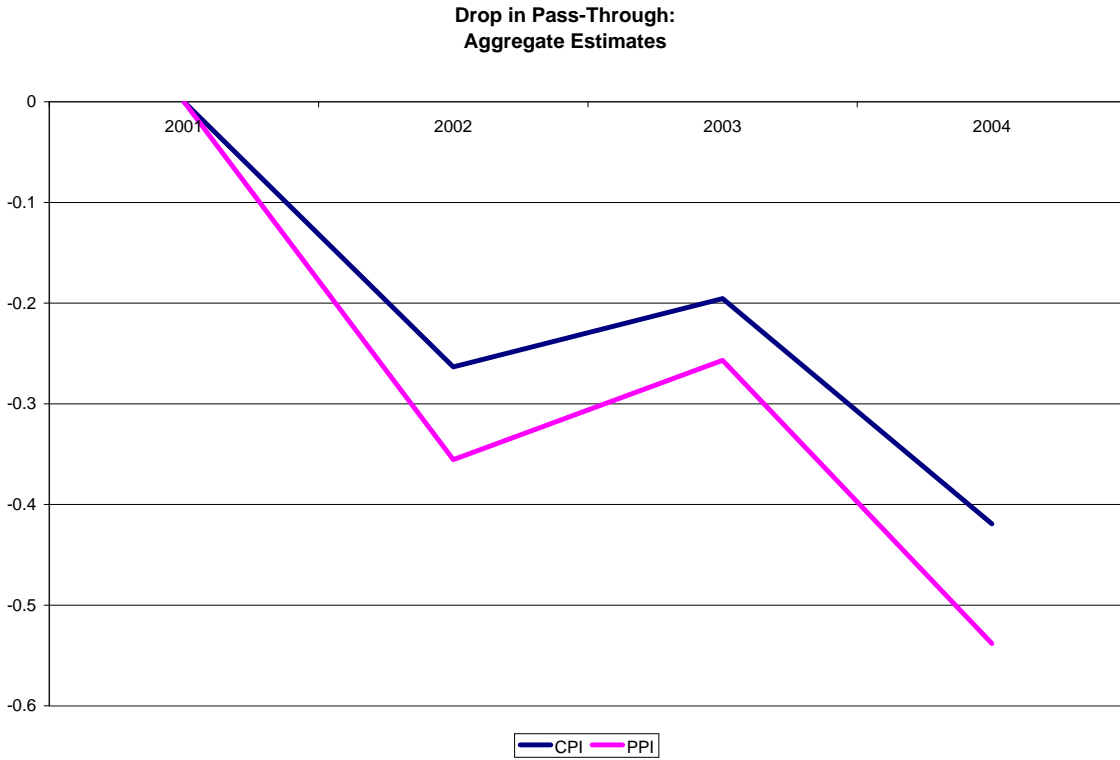
Obviously the point estimates for the CPI are smaller than the PPI because the non-tradable component of CPI is larger (the  $\theta$  is smaller for the CPI items than the PPI ones). However, the drops are relatively the same in both cases.

From the historical point of view it is interesting that the largest pass-through occurs in the year denoted as 2002 that includes the massive devaluation in 2001. Hence, several questions arise, is the drop in pass-through due to the large devaluation? is the drop due to mostly real exchange rate appreciation?

Because of all these complications we have to move to micro data and study the behavior of firm prices. This is the main reason why this particular specification is informative but cannot be interpreted as conclusive.

Finally, before moving on to the individual regressions, I constructed CPI indexes for 10 classifications (For confidentiality of the data I do not identify the sectors). And estimate the rolling window for each of them. Figure 3.1 presents the results.

As can be seen, the estimates are noisier, and some sectors actually experience an increase



in the pass-through. The average in the sample, however, comes down in the same way the aggregate regression does.

### 3.2 Individual regressions

The previous subsection argues that there is a large decline in the pass-through in SAF. The aggregate regression has several problems that could make this result a spurious one. For example, there is item and sectoral composition. It is possible that today the economy has a higher representation of items that have lower pass-through, either because they are in more competitive sectors, or have a smaller imported input share. This change in composition affects the aggregate regression and could be the source of the drop in the pass-through. Additionally, the aggregate regression does not capture the currency composition that Gopinath, Itskhoki, Rigobon (2007) have shown to be so important. In order to deal with all these complains, we estimate the regression at the item level.

	PPI			CPI		
	Pass Through Estimates			Pass Through Estimates		
	Mean	StDev	Tstat	Mean	StDev	Tstat
All	0.204	0.039	5.3	0.124	0.035	3.6
2002	0.551	0.168	3.3	0.373	0.163	2.3
2003	0.196	0.047	4.2	0.110	0.055	2.0
2004	0.295	0.044	6.6	0.178	0.033	5.4
2005	0.013	0.075	0.2	-0.046	0.064	0.7

Table 1: Aggregate Estimates

What is the underlying assumption when we estimate the pass-through at the item level? First, that the share of imported inputs remains constant through time, and second, that the degree of competition at the item level has not change dramatically. The first one is possibly less controversial than the second one. I come back to the second point in the discussion below. In any case, the message is that when micro data is used, in general, it is crucial to be careful about the specification that is going to be estimated. For instance, item and sectoral heterogeneity, as well as price stickiness, can severely affect the micro estimates.

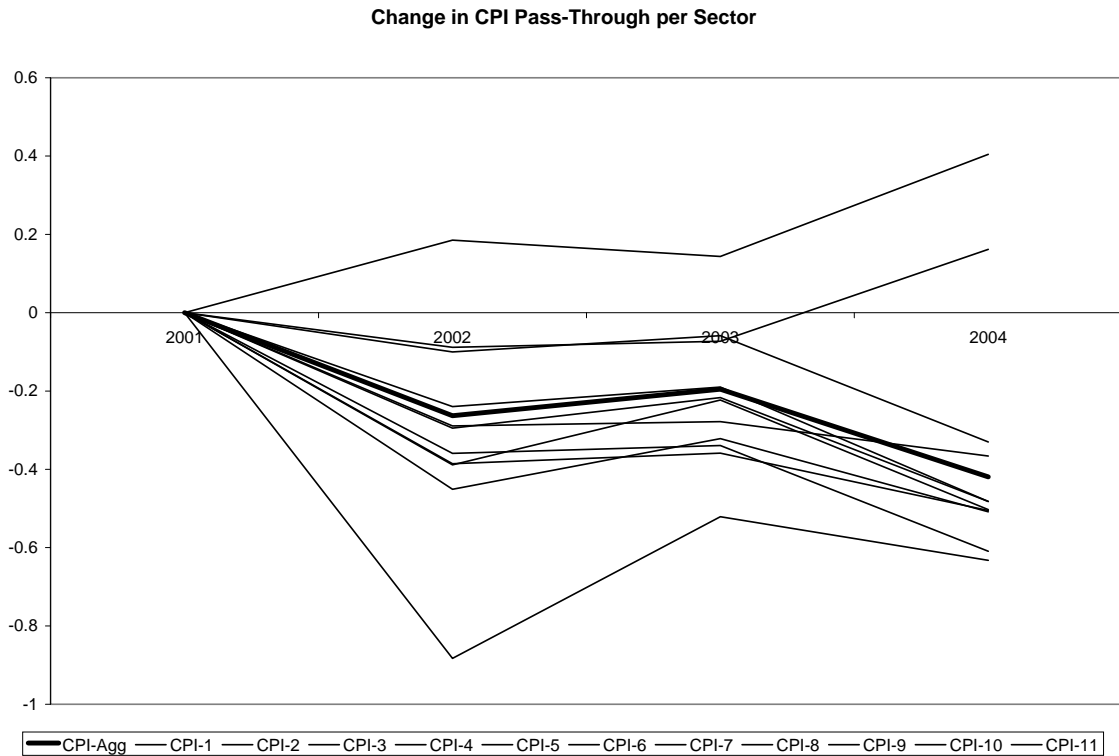
### 3.2.1 A preliminary view at the data

Before running the regressions it is informative to actually look at some data to understand what are the typical patterns present in the item prices.

Individual prices have the following empirical complications: prices are sticky, new bundles or units of sale are introduced, and there are missing observations. Figures 3.2.1 and 3.2.1 show the prices of two items (which cannot be identified for confidentiality reasons) in which we can observe the price stickiness, the fact that new units of sale are introduced, and the problem of missing variables.

In Figure 3.2.1 the item was sold in all these units at all times. The issue is that the Statistics department was only collecting the information for the 700 and 800 grams units. Later, they started collecting the information of the 600 grams, and much later the 500 grams.

From the empirical point of view, this is equivalent to error-in-variables. There are two alternatives of how to deal with this problem. One is to treat each item as a complete different



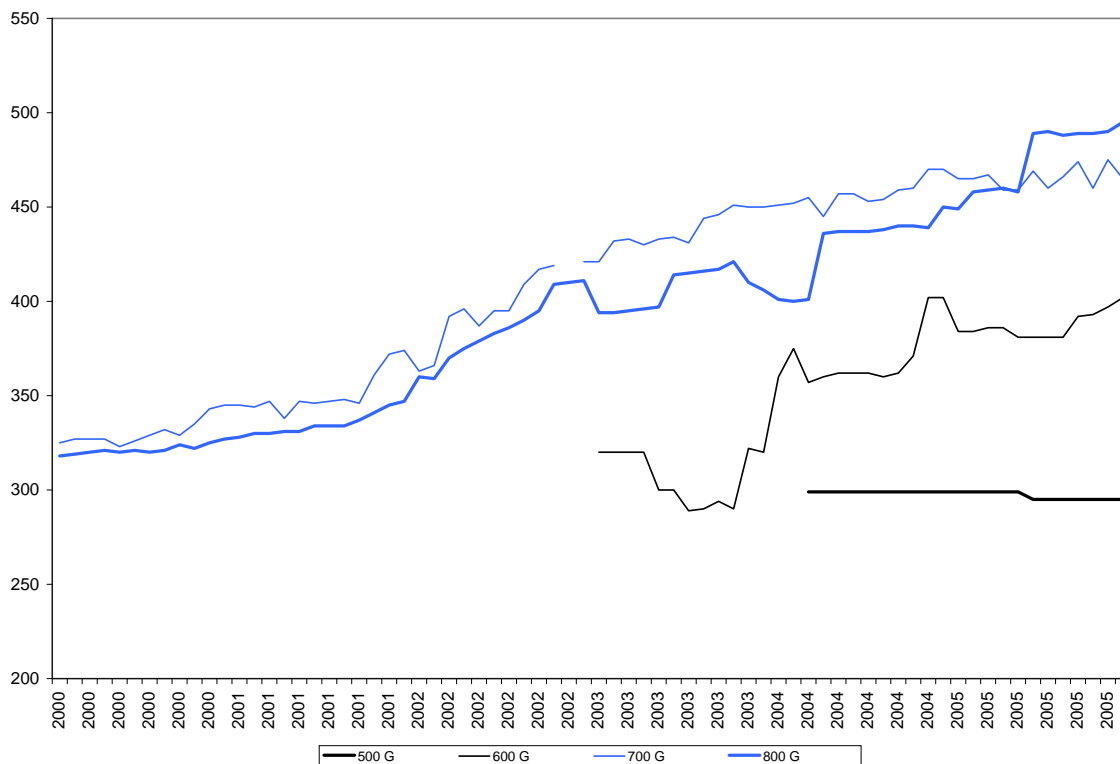
item - meaning, we estimate a pass-through for the 700 grams and another pass-through for the 500 one.

### 3.2.2 Item level pass-through

What is the micro specification that makes sense given the prevailing characteristics in the data? As shown previously, prices are sticky, and therefore, firms pricing decision occur at those times in which there is an actual price change. If the nominal exchange rate follows a random walk, it is easy to shown that in a Calvo pricing model, the pass-through regression should be equal to

$$\Delta p_{t+k,t} = \beta \Delta e_{t+k,t} + \varepsilon_t$$

where  $\Delta e_{t+k,t}$  is the change in the nominal exchange rate between times  $t$  and  $t+k$  (similarly for prices). In this regression, the item had price changes are  $t$  and  $t+k$ ! This is what we mean when we say that the regression has to be estimated conditional on price changes.



The estimate of this regression for the South African economy, every year, produces very similar results as those found in the aggregate regressions. The only difference is that here the drop is smaller than before (20 percent).

In Figure 3.2.2 the estimates for the CPI and PPI are shown. Notice that the qualitative implications of this model are similar to the aggregate regression, and that for both CPI and PPI the drop is very similar.

One question that immediately arises from this exercise is if appreciations and depreciations are similar. In other words, the question is if the drop in item pass-through could be explained by the fact that in the first part of the sample, there is a huge depreciation of the exchange rate, and in the second part of the sample there is an appreciation. Hence, it is possible that the drop is just highlighting the differential response to devaluations and appreciations.

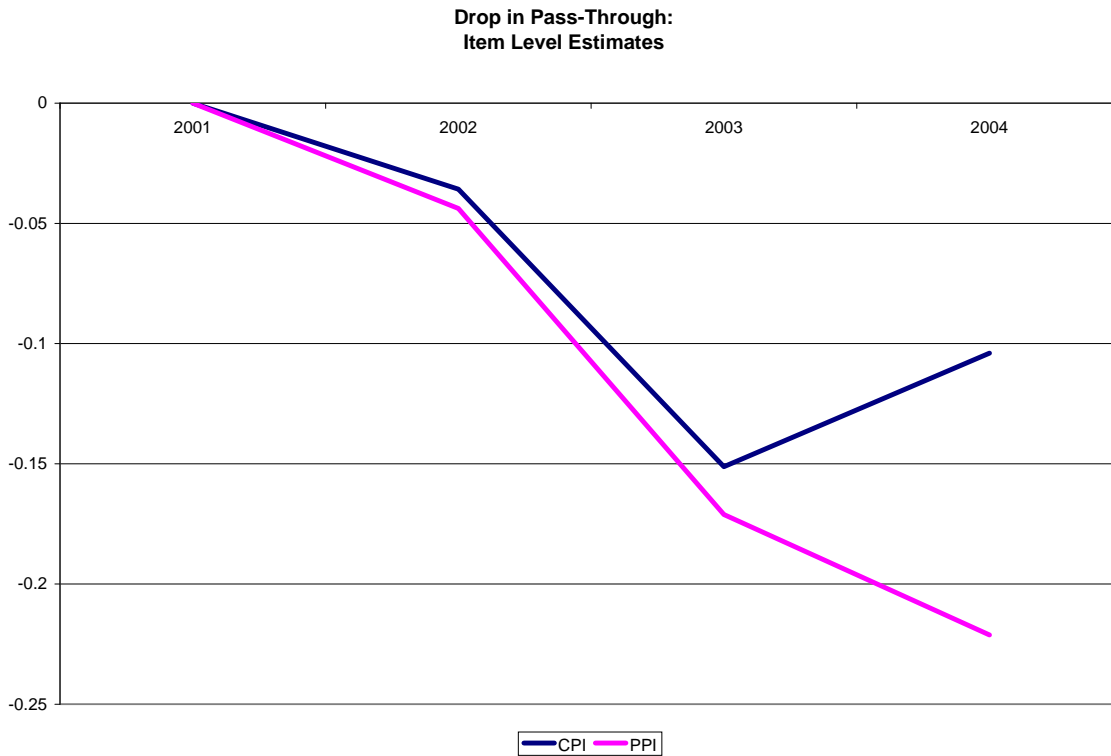
Second it is possible that the degree of stickiness is changing through the sample, and



that affects the estimates. I believe this explanation is unlikely because the regression we are estimating supposedly has taken care of the stickiness because we are estimating conditional on price changing. Therefore, the only piece that could be missing is the strategic complementarity from the price stickiness.

In order to explore these possibilities, we first look at the behavior of price changes across time and for the different exchange rate movements. In figure 3.2.2 we present the monthly exchange rate movement together with the probability that prices change, for both the CPI and the PPI.

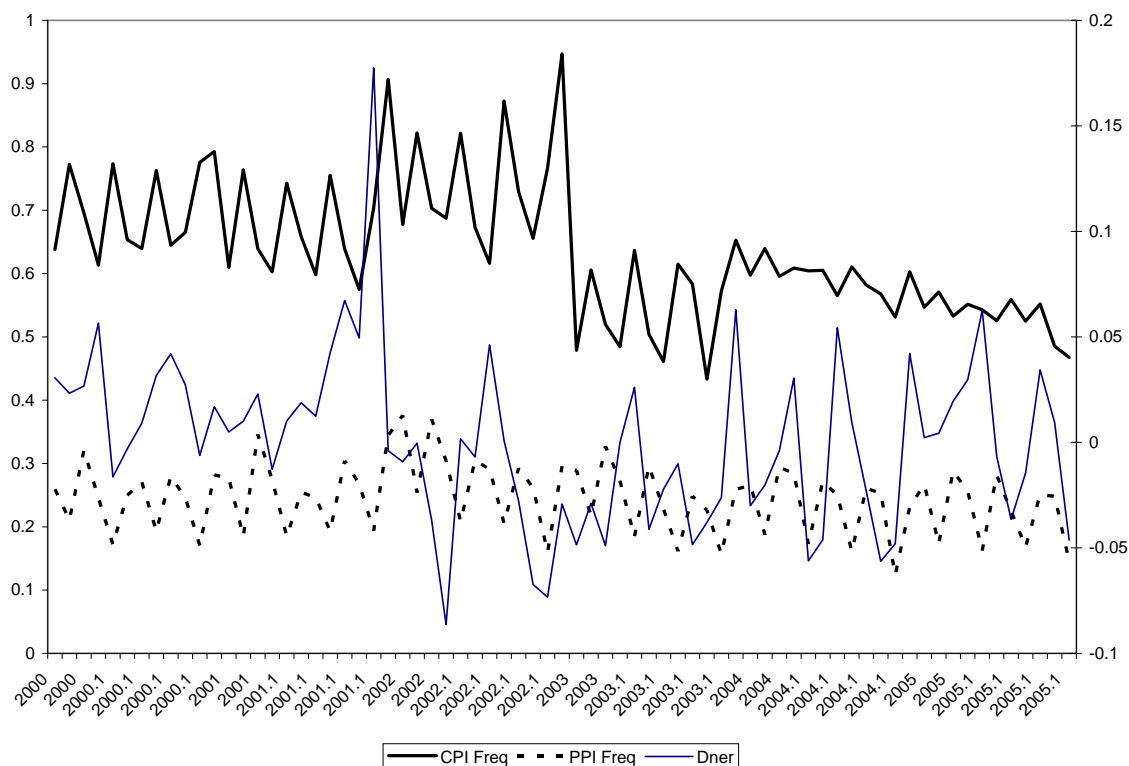
One of the most striking facts from this figure is that the probability of price changes for the CPI and the PPI has a small effect by the exchange rate movement. First, notice that the PPI (measured on the left hand side axis) has a probability of change close to 25 percent irrespectively of the exchange rate movement, and sign of the exchange rate movement. The CPI experiences a little bit more movement when exchange rate repreciate significantly,



however, the effects are small in the end.

In fact, Figure 3.2.2 and Figure 3.2.2 show the relationship between stickiness and the probability of price change for different industries in South Africa. Notice that the relationship is slightly positive, although insignificant, for the CPI and it is negligible and with the wrong sign for the PPI. In the end, these two figures argue that the behavior, if affected by the sign and size of exchange rate movements, they have a very weak relationship.

In a standard sticky price model with menu costs, it must be the case that a larger exchange rate deviation should increase the probability of prices moving, independently of what occurs to the pass-through. The data do not show this pattern — at least, not as strong as we would have expected if the prices are governed by menu costs. The results are consistent with a Calvo pricing. Hence, the question of asymmetry is mainly about pass-through conditional on exchange rate movements. This is hard to do in South Africa given the short data set we have. However, a preliminary look at this question is provided in the



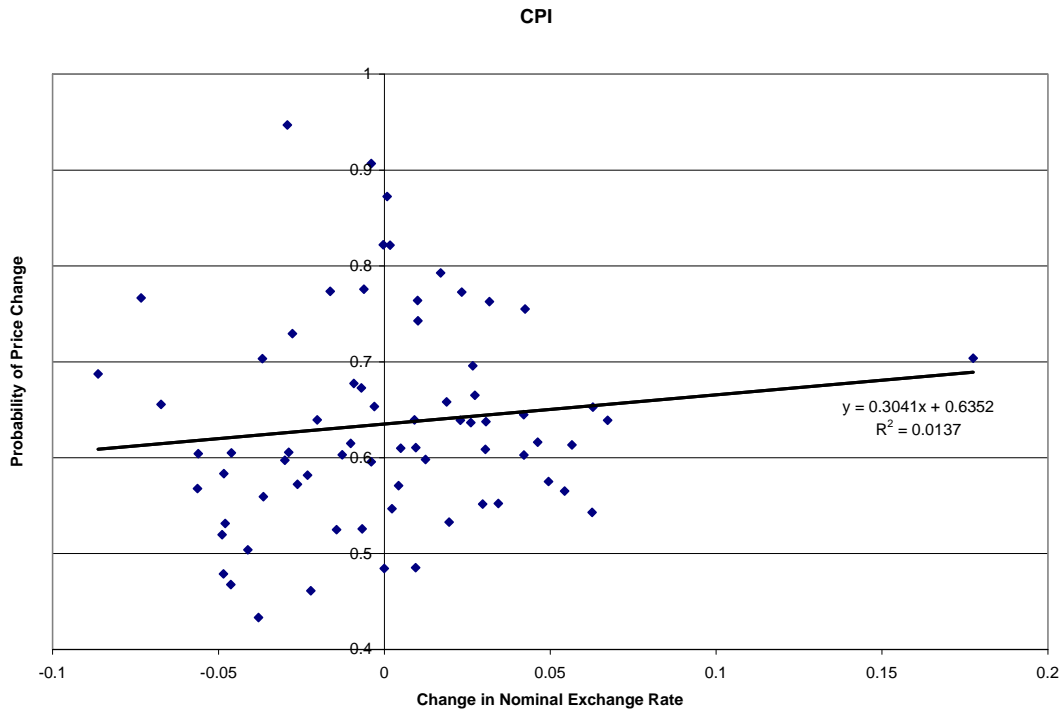
following figure where I study the behavior of the pass-through for the different levels of exchange rate movements.

We computed the pass-through for different sub-samples, depending on the observed exchange rate movement. The relevant subsamples are appreciations of more than 5 percent ( $<-0.05$ ), between 5 and 0 percent appreciation, between 0 and 5 percent depreciation, between 5 and 10, and then more than 10 percent depreciations.

As can be seen, the pass-through indeed increases slightly with the size of the exchange rate depreciation, however, we cannot reject the hypothesis that all estimates are the same. Still, these findings might suggest that part of the pass-through decline observed along the years could be the outcome of differential desired pass-through to depreciations and appreciations.



# Price Stickiness

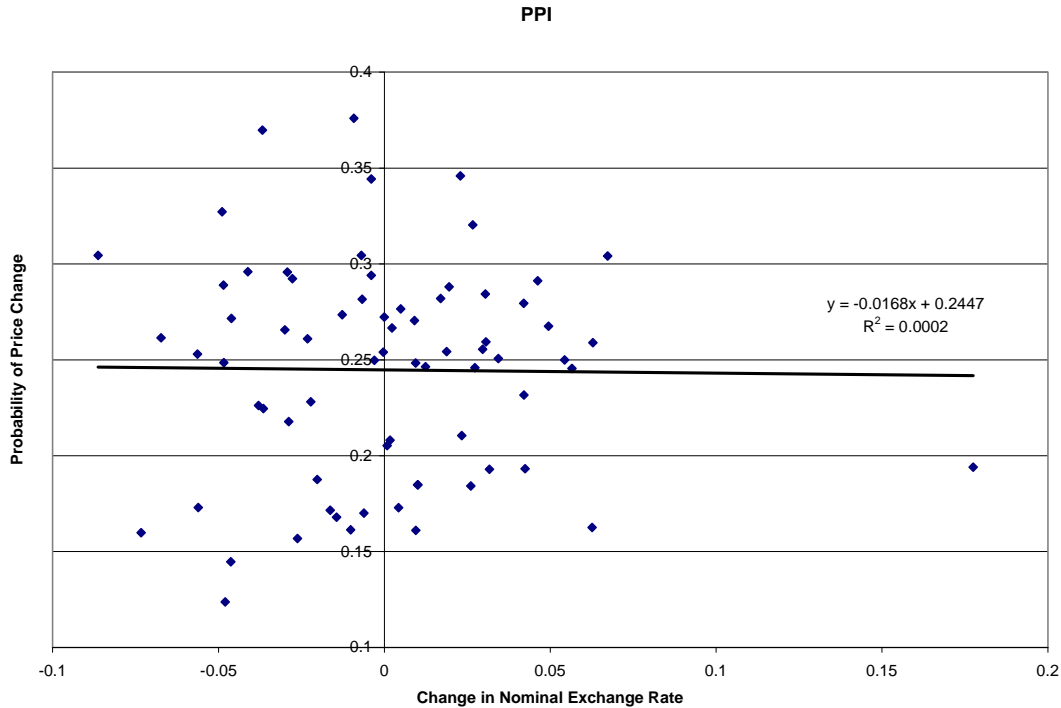


## 4 Interpretation and Discussion

In this paper, I have presented clear evidence that there is a sizeable decrease in the exchange rate pass-through for CPI and PPI in South Africa. This result is found both on the aggregate regression and at the item level. It is very important to highlight that this is not always the case when similar regressions are estimated for other countries, i.e. the US. In my paper with Gopinath and Itskhoki we find that conditional on the currency of invoicing and the price adjustment the decline is null. Hence, the finding in South Africa that the same regression indeed reflect a change in the micro regression is a very significant one.

What are the possible explanations? There are three distinct possibilities: one is the story that this paper is trying to push: that the credibility of the central bank has improved. Second, it is possible that the degree of competition in the economy has changed. Finally,

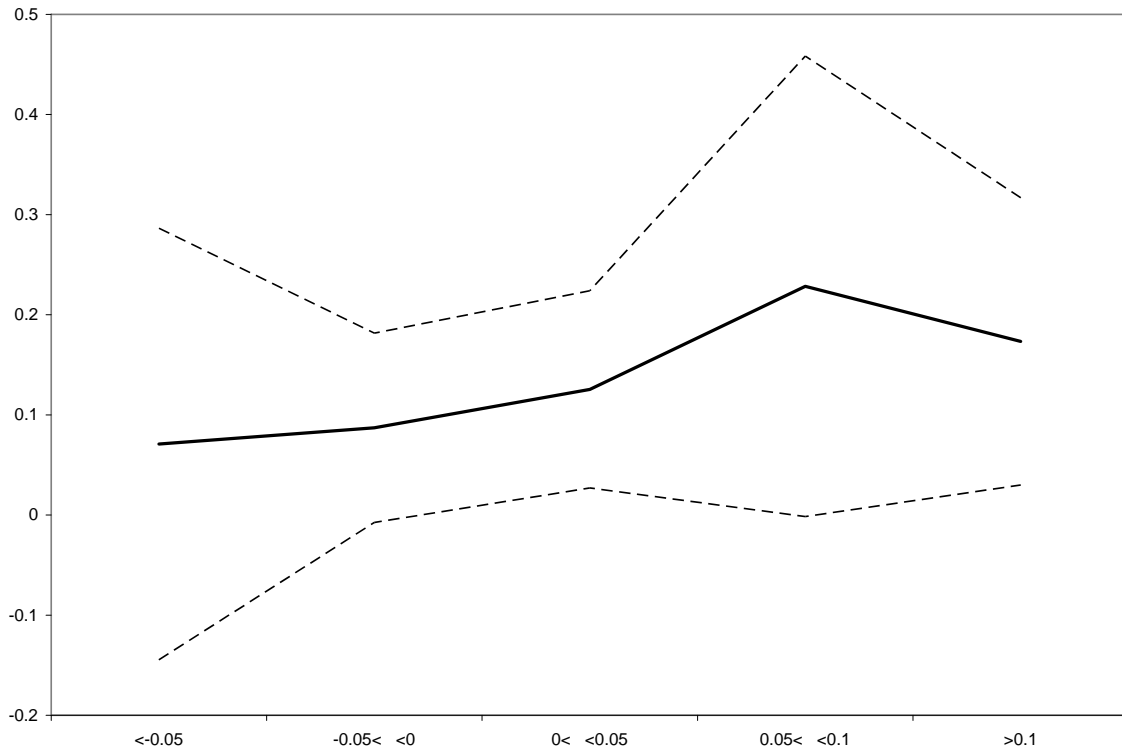
# Price Stickiness



it is possible that firms react differently to depreciations and appreciations, or to the size of the exchange rate depreciation, and the decline reflects more a change in the size of the shocks, rather than a change in behavior.

The order in which I chose to enumerate the possible explanations is not random. Indeed, they capture my views about what I think are the most reasonable possibilities. Let me proceed in reverse order.

From the theoretical point of view it is perfectly possible that larger devaluations imply larger pass-through. specially, as we have shown, that the exchange rate depreciation has a very small effect in the probability of adjustment. In other words, in a Calvo pricing model, a larger devaluation might imply a larger desired pass-through - maybe markups are changing, or there are significant changes in the degree of decreasing returns to scale. Although this is a clear possibility, the estimates we obtain are very close to each other. They cannot explain



the differences we observe in the data. For instance, there is a decline in the pass-through of an average of 25 percent. If in the data there were ONLY depreciations between 5 and 10 percent in the first part of the sample, and there are ONLY appreciations of more than 5 percent in the later part of the sample, the pass-through would have dropped from 22.8 to 8.7. A drop of 14 percent. And this is assuming a completely unrealistic process of the exchange rate that we have already shown it did not take place (Figure 3.2.2). So, even though this is a possible explanation it has no quantitative relevance.

The second possibility comes from a change in the degree of competition in the economy. For instance, if there is a sizeable increase in the degree of competition, then items will have smaller pass-throughs on average. The idea is that in a very competitive market, firms have to absorb the cost shocks - one of which can be the exchange rate movement. Just by observing the South African economy, it is hard to justify an increase in the degree of competition. Markups have not fallen, and the oligopolistic behavior of firms does not seem to have changed dramatically in the last 5 years.

Because these two explanations seem to be, at best, weakly contributing to the reduction of the pass-through, and because indeed the central bank has aggressively pursued a conservative monetary regime, I believe the decline in the pass-through is explained by an increase in the credibility of the monetary authority.

Of course, this is not the end of the research. My conclusion is clearly a conjecture, and reflects my strong priors about what I think has taken place in the last half decade. Further research studying other mechanisms to detect central bank credibility are clearly the following steps.