Estimating price rigidity in coffee markets:  
A cross country comparison

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Abstract

Price rigidity theories explain why a firm may not change its prices in response to changes in demand and cost conditions. Understanding rigidity and its determinants is important in evaluating the potential effectiveness of monetary policy. This paper uses error correction models to estimate the degree of price rigidity in the coffee markets of 16 different countries. A high degree of rigidity was found in seven countries, while relatively responsive prices were found in the remaining countries. A general conclusion that can be drawn from the study is that the price adjustment occurs within two quarters after the shock is imposed. The observed rigidity seems to be largely determined by the high degree of market concentration. The economic margin resulting from imperfect markets allows a firm not to adjust prices to cost changes.

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1. Introduction

How prices are adjusted by firms to external shocks has generated considerable interests to industrial organization theorists and has important implication for new Keynesian macroeconomics. It is crucial to understand the nature of the price adjustment processes for the appropriate design and conduct of monetary policy. Despite its central importance in micro and macro theories and relevance in economic policies, there are only a limited number of empirical studies (Blinder et al., 1998; Dutta et al., 2002; Dhyne et al., 2005).

Price rigidity theories provide hypotheses about why a firm may not choose to change its prices in response to changes in the demand and cost conditions it faces. There are a number of different explanations for the existence of nominal price rigidity, each following different theoretical routes to explain the sluggishness of price changes. Blinder (1991) and Blinder et al. (1998) pointed out that the economic research has been singularly unsuccessful in conducting empirical tests on the validity of particular rigidity theories. Although it would be nice to know both the “degree of price rigidity” and the underlying explanations for its existence, a measure of the degree is important on its own sake.

There are a number of ways in which price rigidity has been measured in the empirical literature. Perhaps the most popular method is simply to look at the size and the frequency of price changes in a given period. Until recently, some of the best sources of information for the size and frequency of price changes for particular categories of products were Carlton (1986), Viqueira (1991), Lach and Tsiddon (1992), Kashyap (1995) and Blinder et al. (1998). A number of recent studies include Baharad and Eden (2004), Bils and Klenow (2004), Herrmann et al. (2005), Alvarez et al. (2005), Fabiani et al. (2005) and Nakamura and Steinsson (2006a). The study of Alvarez et al. is based on product level price data used to construct the Consumer Price Index (CPI) and Producer Price Index (PPI) in the countries in the Euro area. Nakamura and Steinsson used similar set of data used for the construction of CPI and PPI in US. These studies are the first two studies which covered wide range of products both in the consumer and producer categories. The summary finding of these studies is that price changes approximately once a year. Notably, this finding is similar to the finding of the studies undertaken in the 1980s and 1990s mentioned above, as pointed out by Nakamura and Steinsson, “[t]he conventional wisdom from this literature was that prices adjusted on average once a year” (p.1).

The econometric analysis of individual price data has provided two alternative measures of price rigidity. One of them is obtained from the discrete choice modeling framework and measures the probability of price change with respect to cost and demand shocks. The studies that fall in this category include Cecchetti (1986), Dhalby (1992), Owen and Trzepacz (2002) and Campbell and Eden (2004). These studies attempt to examine the factors that determine the incidence and size of price changes. Within the framework of dynamic econometric modeling such as vector autoregression (VAR) and vector error correction models (VECM), Peltzman (2000) and Dutta et al. (2002) estimate the time dimension of price changes, i.e. the number of period price adjustment takes place after a cost or demand shock is being initiated. This notion of price rigidity is of considerable interest to macroeconomists. In the literature, it is also referred to as the price transmission or pass through effect.

In this paper we examine the price rigidity across 17 countries using publicly available data on coffee prices at different stages of production and distribution (farm, wholesale and retail sectors). The frequency of observation is monthly covering the period from 1976:1 to 2004:12. The countries considered in alphabetical order are Austria, Belgium, Luxemburg, Denmark,
Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom (UK) and United States of America (USA). ¹ However, since the source of data merges together the retail coffee price data of Belgium and Luxembourg, we consider them as a union (referred to as Bellux). Using VECMs, the transmission of shocks to the retail sector of coffee in these countries was modeled.

This paper contributes to the empirical literature of price rigidity in a number of ways. First, there are only a limited number of time series studies which provide an empirical analysis of price rigidity, as emphasized by Carlton (1986); Gordon (1990); Kashyap (1995); Dutta et al. (2002).

Second, we examine the price rigidity in the way that has macroeconomic policy implications. According to Blinder (1991), a more important question, from a macroeconomic perspective, was to determine how far price adjustment lags behind demand and cost shocks. In this study we follow Blinder’s suggestion as we believe that this type of study can provide us with a better understanding of (1) the monetary policy transmission process and (2) underlying inflation. Price rigidity, in our study, is measured as the effect of cost and foreign price changes on the domestic retail prices. In this context the higher the lag the greater is the degree of price rigidity.

Carlton and Perloff (1994) defined price rigidity as a situation when price does not respond to variation in costs and demand. This implies that a price can have high frequency in terms of the number of times it changes in a given period, but it can still be subject to high degree of rigidity if it does not respond to underlying changes in demand and supply. Conversely, a price with a low degree of rigidity may experience infrequent price changes. For the purpose of monetary policy and measures of underlying inflation, it is important to identify whether the price response is due to underlying pressure of the economy. Dutta et al. (2002, p.1876) observed that “…at least some of the frequent price changes we observe in the data may not be in response to changes in supply and demand conditions and therefore, may not be informative about the extent of price rigidity/flexibility”.

Third, the study uses prices of a widely consumed product, coffee. Coffee is currently the second most traded commodity in the world (after crude oil). The reason it is so widely traded is because of high volume of trade of both coffee bean and processed coffee. There are some advantages in studying price rigidity with a product subject to high degree of international trade. The theory of spatial competition would suggest similar pricing behavior across countries. Therefore, variation in price rigidity could be attributed to the upstream stages of distribution such as difference in the market features, policy and economic environment specific to that particular importing country. We control, at least to some extent, for the differences in the features that may result in the variation of price rigidity up to the manufacturing level.

Although the retail prices of coffee in all the countries do not relate to the same item, these retail prices are average and listed prices of coffee collected by the respective countries statistical agencies for the purpose of calculation of the consumer price index. Ideally, we would have preferred to have transaction price data of some brands of coffee because of their appropriateness in the study of price rigidity (Carlton, 1986; Lach and Tsiddon, 1992; Wynne, 1995; Levy, 2002). However, the retail price data we are using are quality adjusted and reflect the movement of coffee prices in the respective countries.

Finally, until recently, there were no studies that examined the variation of price rigidity across countries. Most of the existing studies have examined the variation across different varieties

¹ The choice of the countries has been dictated by the ease of availability of data.
within a product group in a single country (for example, Kashyap, 1995; Dutta et al., 2002; Levy et al., 2002) or across different product groups in a single country (for example, Carlton, 1986; Kashyap, 1995; Bils and Klenow, 2004; Herrmann et al, 2005, Campbell and Eden, 2005).

The few studies that looked at the variation across countries are Alvarez et al. (2005) and Fabiani et al. (2005). However, our study is different in many respects. In the Alvarez et al. study, a key measure of rigidity that was used for the basis of comparison was the frequency of price change. In our study, the comparison across countries is drawn with respect to the dynamic impact of retail prices to external shocks. However, the firm interview study of Fabiani et al. attempted to examine the nature in which the firms behave to cost shocks based on related interview questions. Thus the finding is based on the perception of the respondent on a particular scenario, and therefore, may not be appropriate for this kind of analysis. The firm level survey may be more useful to understand the underlying rationale of the behavior of the price setting practices and make a cross-sectional comparison. However, the surveys taken at one point of time, and therefore, are not suitable for capturing dynamic features of the price adjustment process.

The paper is organized as follows. A description of the data is provided in Section 2. Section 3 sets out the econometric model used for estimating price rigidity. A number of sensitivity tests were conducted on the model and these tests and the results are described in section 4. Section 5 is devoted to a discussion on the possible causes of price rigidity and variations across countries. We conclude in section 7.

2. Data Descriptions

The study uses 18 monthly time series data on nominal prices. Among these series, one series relates to farm prices of coffee beans, one relates to wholesale prices and the remaining 16 series relate to retail prices of coffee at 16 different countries studied in the paper. The data is collected from the International Coffee Organization ( ICO) website. In addition, the paper uses 16 series of consumer price indices (CPI) of the 16 respective countries.

Among different varieties of coffee beans produced in different countries, for the farm price we used the price of Brazilian Arabica produced in Brazil. This is because (1) the variety is one of the dominant varieties and (2) Brazil is the largest coffee producing country in the world. In 2004, Brazil exported approximately thirty per cent of the total coffee bean exports of the world.

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2 In recent years, a number of studies were undertaken by the Inflation Persistence Network (IPN) of the European Central Bank (ECB). One set of study is based on firm level surveys conducted in nine countries in the euro area. Fabiani et al (2005) summarizes the findings of the survey of 11,000 firms in Austria, Belgium, France, Germany, Italy, Luxembourg, the Netherlands, Portugal and Spain. These countries together accounted for around 94 per cent of the GDP in 2005. Another set of study is based on the product level CPI and/or PPI data of different countries in the Euro area. A summary of these studies are provided in Alvarez et al. (2005).

3 The ICO website, www.ico.org, is a rich source of data for coffee production, consumption, trade and prices. Among others, it has various time series on nominal prices of coffee beans at the farm and wholesale level, and nominal retail prices in different countries. All prices are in US dollars.

4 The CPDs are “CPI: All Items”, collected from the OECD website.

5 The Columbian mild is the next important variety in terms of production. We estimated the same models with the Columbian variety. The results obtained were similar.

6 Author’s own calculation using export data obtained from ICO website.
For the nominal wholesale price, we used the ICO composite index which is constructed from four other indices, each corresponding to a variety of coffee bean. Figure 1 plots the composite index and its four component indices and table 1 provides the pairwise correlation coefficient among these indices. Mehta and Chavas (2004) mention that since wholesale price of different varieties of coffee beans co-move, much can be learnt about the aggregate behavior from one of the wholesale price indicators. The sample range for the farm and wholesale prices used in the study is 1976:1 – 2004:12.


We provide some descriptive statistical analysis to better acquaint ourselves with the data set. Figure 1 shows the presence of high degree of variation of wholesale prices over the entire sample period. In addition, there are some marked increases and decreases in some periods, possibly caused by adverse weather conditions. The wholesale prices show a slightly negative trend. In order to check whether there have been any changes in the mean prices, we divide the whole sample period in two ways. First, by dividing it into three sub-periods: 1976:1-1985:12 (period I), 1986:1-1995:12 (period II) and 1996:1-2004:12 (period III) and, second, by two periods: 1976:1-1989:6 (pre-ICA period) and 1989:7-2004:12 (post-ICA period). The calculated means and their standard deviations are reported in table 2. The means of farm prices are almost the same among the sample sub-periods. However, the means of wholesale prices decline gradually over different sample periods; for example, it was 143.87 cents in the pre-ICA and 81.40 cents in the post-ICA period.

Figure 3 plots the nominal retail prices of 16 countries. One common feature of the graphs is that they exhibit high degree of variation with some marked changes in some periods. Within these ups and down, some of the retail prices appear to have trends. For example, while a positive trend can be seen in prices of Italy, Switzerland and UK, a negative trend is visible in case of prices of France. Table 2 reports the means of the retail prices for the whole sample period and the sample sub-periods. In 9 out of 16 countries, the mean price went up in the post-ICA period as compared to that in the pre-ICA period. This is the case even though the nominal wholesale price decreased between these two periods.

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7 ICO composite index is a weighted average of four other component indices. These four component indices relate to four different varieties of coffee: Brazilian Natural, Columbian Mild Arabicas, Other Mild Arabicas and Robustas.
8 Excessive frost in 1985-86, 1994-95 and 1997 had adverse impact on the production of coffee beans.
9 This division of sample period into three sub-samples is arbitrary. For most countries, period 1 and 2 have 120 observations each and period 3 has 108 observations.
10 ICA refers to International Coffee Agreement. ICA............
It is interesting to look at the ratio of wholesale to retail prices to understand the relative importance of coffee beans to the processed coffee sold in the retail market. We plot the graphs of the ratios in figure 4. Although the decline in the ratio is more pronounced in some countries than the others, without any exception, all of them exhibit negative trends. The means of the ratios in different sample periods are provided in table 3. In some countries, the ratio declined by more than half between the pre-ICA and post-ICA periods; for example, Italy from 0.4 to 0.16, Japan from 0.16 to 0.07 per cent, UK from 0.18 to 0.07 per cent and USA from 0.51 to 0.25 per cent. One can conclude that the relative importance of coffee beans in the total value of production of coffee has declined gradually over the sample period.

With the exception of Japan, the real retail prices have fallen steadily in all the countries. The real retail prices, shown in figure 4, are calculated by dividing the nominal prices with the country specific consumer price indices. One should note that the fall in the real price of coffee beans, both at the farm and the wholesale level, is expected to be much more pronounced because much of the coffee beans are produced in countries experiencing relatively high rate of inflation. Therefore, one can expect that the ratio of real wholesale to real retail prices fell at a faster rate than the corresponding ratio of nominal wholesale to nominal retail prices. However, the fact that real retail price of coffee declined over years indicates the importance of coffee bean prices in the determination of coffee prices at the retail level.

There exists high degree of correlation among the real retail prices. Table 4 shows the pair wise correlation coefficients among the nominal retail prices for different sample periods. The correlations among the real prices are provided in table 5. A comparison between these two sets of correlation coefficients shows that the real prices move together much closer than the nominal prices. This implies that the country specific factors play an important role in the determination of nominal prices.

The augmented Dickey-Fuller (ADF) and Perron’s test for structural change (Perron) have been used to test for the stationarity of the series. While the ADF test shows that 11 out of 18 series are stationary, the Perron test finds only five series as stationary. The five series found to be stationary by Perron test are also stationary in the ADF test. Given this discrepancy, one may argue that the results obtained from the above two tests are inconclusive. However, the results demonstrate that the series in our study are either ‘near unit root’ or ‘unit root process’, because the estimated characteristics roots, as reported in the column 6 in table 7 and column 10 in table 8, are very close to one. For the purpose of modeling, this led us to use the first difference of the respective series.

In conducting the ADF, regression equations of the following form have been estimated:

$$\Delta y_t = a_0 + a_1 y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta y_{t-i} + \epsilon_t \tag{1}$$

The lags of the first difference have been chosen using Akaike’s information criterion (AIC). Rejection of the null hypothesis $$a_1=0$$ would mean that the process is stationary. The results of the ADF tests reported in table 6 shows that while the farm price is stationary, the wholesale price is non-stationary. Among a total of sixteen retail prices, six are found to be non-stationary. Among the 7 series reported to be non-stationary, only one of them is non-stationary on a borderline case and others are non-stationary with very low t-statistics. However, one should note
that the power of the test, the probability of correctly rejecting the null hypothesis of a unit root, is very low, particularly when the estimated characteristic roots are very close to unity. The characteristic roots reported in column 6 of table 6 range between 0.934 and 0.982.

Insert table 6 here.

In the presence of a structural break, the ADF test statistics are biased towards the non-rejection of unit roots. In order to test for the suspected structural break due to the collapse of International Coffee Agreement in June 1989, we conduct Chow tests on equation (1). Table 7 reports the estimated F statistics and the respective probability values. According to the tests, evidence of a structural break is found in four series; retail prices of Italy, Spain, Switzerland and UK. When ADF tests were conducted on the whole sample for the above four series, the null hypothesis of a unit root could not be rejected only for the series of Spain.

A common econometric procedure for testing the unit root hypothesis with a known break point is to split the sample and conduct the ADF test on each part. The problem with this procedure is a very low power due to the reduction in the degrees of freedom in estimation for each of the equations (Perron, 1989). Perron developed a methodology to test the unit root hypothesis that treats a known structural break as exogenous. He showed that the test has more power than conducting various ADF tests on split samples. In order to check for the unit root hypothesis we estimated the following equation which Perron referred to as the “crash model”.

\[ \Delta y_t = a_0 + \mu_1 D_L + \mu_2 D_P + a_1 y_{t-1} + a_2 t + \sum_{i=1}^{k} \beta_i \Delta y_{t-i} + \varepsilon_t \]  

where, \( D_L = 1 \) for \( t \geq 1989:7 \) and zero otherwise; \( D_P = 1 \) for \( t=1989:7 \) and zero otherwise. The null hypothesis of the test is a unit root process having a one time change in the level at the break. Therefore in our model, the null hypothesis refers to \( a_1 = 0, a_2 = 0 \) and \( \mu_1 \neq 0 \). Under the alternative hypothesis, the series is trend stationary with a permanent one-time break. In our equation this relates to \( a_1 < 0 \) and \( \mu_1 \neq 0 \). The trend coefficient \( a_2 \) can take any value including zero depending on whether the series has a deterministic trend or not. The results of the estimated equation are reported in table 10. The calculated t statistic for the null of unit root is compared with the Perron’s critical values for the appropriate lambda value. The results show that only 5 of the 18 series are stationary without any evidence of structural change at the break point. These 5 series relate to retail prices of Italy, Norway, Netherlands, UK and US. The remaining 13 series are unit root process and, only three of these series, farm price, wholesale price and retail price of France, indicate having a break at the point of collapse of the ICA.

Insert table 8 here.

The findings from Perron’s crash model receive additional support because of the similarity of the results across equations. The estimated characteristic roots are very close ranging between 0.92 and 0.98. The t-statistics of \( a_1 \) are very similar; 14 of them are in the range between 3 and 5. One more similarity is related to deterministic trend. The estimated coefficients and their corresponding standard deviation of the trend term indicate the absence of deterministic trend in any of the equation.

\[ \text{Lambda is the ratio between the break point and the total number of observations. Perron’s critical values depend on this ratio. When the ratio is 0 or 1, then the critical values collapse to the corresponding Dickey-Fuller critical values.} \]
The above findings from the ADF and Perron’s test show that there exists dissimilarity in characterizing whether a series is stationary or non-stationary. However, the characteristics roots are very close to unity according to both tests, and the low power of the tests for points close to unity may be the reason behind the conflicting results. Enders (2004, p.210) with the help of a Monte Carlo experiment showed that the test has very low power to detect near unit root series. However, having said all this, one can conclude that the series are either borderline stationary (near unit root) or unit root process. Therefore, for the purpose of modeling, we used the first difference of the series. The first difference of a unit root process de-trend the series.\footnote{To provide additional support, we tested the unit root hypothesis on the first differences of the series. The null hypotheses of unit root are rejected in all cases at 1 per cent significance level.} For the near unit root process, Monte Carlo experiments have shown that short-run forecasts from differenced models are usually superior to the forecasts from the series on levels (Lutkepohl, 2006).

IV. The econometric model

In this section, we describe the cointegration analysis and the econometric model used for estimation. Our primary interest in this study are to evaluate the impact on the nominal retail prices to (1) cost shocks and (2) shocks originating from large coffee consuming countries (referred to as foreign shock).

Coffee beans are one of the major raw materials in the production of processed coffee and as such provide an important source of potential supply side shocks. There are two possible data sources for coffee bean prices: (1) the farm gate prices or (2) the wholesale prices. As mentioned before, we used ICO composite index for wholesale prices as the source of cost shock. The scenario here is similar to the $n$ stages of production linked by a chain of production promulgated proposed by Blanchard (1993). An implication of Blanchard’s theory is that, the closer the two stages of production are, the shorter the number of lags (in the number of periods) between the cost changes and the price change. In other words, the degree of price rigidity will be calculated as lower when cost shock originates from the wholesale sector as compared to when it originates from an upper stream stage of production, such as farm sector.

However, one should note that a change in the cost from any stage does not have to physically pass through all or any of the intermediate stages to have impact on prices at any downstream stages of production. For example, it is possible that a change in the farm level price can have a direct impact on the retail price rather than passing through the wholesale sector. Therefore, the impact of a price change at the farm level can impact on the retail price either directly or indirectly. Due to the possibility of the existence of multiple channel relationship, Dutta et al. (2002) estimated a model including three stages of production, farm, wholesale and retail stages.

Two of the largest coffee importing countries of the world are the US and Germany. In 2004, the US and Germany imported around 20.1 and 15.2 per cent of the coffee bean importing countries of the world.\footnote{The third largest coffee importing country of the world is Japan, accounting for 6.3 per cent of the total coffee bean imports.} We took a weighted average of coffee prices in the US and Germany to get a representative price of the large coffee consuming countries (Figure 5). In this study, we refer to this price as ‘foreign price’ and any shock originating from this market as ‘foreign shock’.\footnote{The retail prices of the US and Germany may refer to different types of coffee. Therefore, before we took the weighted average, we demeaned the prices. For weights, we use the yearly import volumes obtained from the ICO website.} The
idea is to assess the impact of shock originating from a large coffee consuming country on the domestic retail price.

We will model a three equation system. These equations relate to wholesale, retail and foreign market. The structural vector auto-regressive (SVAR) model is as follows:

\[ Sx_t = \Gamma_0 + \sum_{i=1}^p \Gamma_i x_{t-i} + \varepsilon_t \]

(1)

where, \( x_t = [x_t^r, x_t^f, x_t^w] \) is a (3 x 1) vector of prices, \( x_t^r, x_t^f \) and \( x_t^w \) are the retail, foreign and wholesale prices, respectively. \( S \) is a (3 x 3) matrix of contemporaneous coefficients,

\[
S = \begin{bmatrix}
1 & s_{rf} & s_{rw} \\
s_{fr} & 1 & s_{fw} \\
s_{wr} & s_{wf} & 1
\end{bmatrix}
\]

\( \Gamma_0 \) is the (3 x 1) vector of intercepts. \( \varepsilon_t = [\varepsilon_t^r, \varepsilon_t^f, \varepsilon_t^w] \) is a (3 x 1) vector of white noise disturbances.

A standard form vector auto-regressive (VAR) model is obtained by pre-multiplying equation (1) by \( S^{-1} \).

\[ x_t = A_0 + \sum_{i=1}^p A_i x_{t-i} + e_t \]

(2)

where, \( A_0 = S^{-1}\Gamma_0, A_i = S^{-1}\Gamma_i \) and \( e_t = S^{-1}\varepsilon_t \).

Since \( \varepsilon_t^r, \varepsilon_t^f \) and \( \varepsilon_t^w \) are white noise processes, it follows that \( \varepsilon_t^r, \varepsilon_t^f \) and \( \varepsilon_t^w \) have zero mean, constant variance and are individually serially uncorrelated. However, \( \varepsilon_t^r, \varepsilon_t^f \) and \( \varepsilon_t^w \) are correlated with each other.

Identification restriction

To analyze the impact of a structural shock on the endogenous variables identification restrictions need to be imposed on the model. We set \( s_{rf}, s_{rw} \) and \( s_{fw} \) equal to zero, which led to a model recursive in nature. Dutta et al. (2002) imposed similar identification restriction. Thus the matrix of contemporaneous coefficients of the estimated model is,

\[
S = \begin{bmatrix}
1 & 0 & 0 \\
s_{fr} & 1 & 0 \\
s_{wr} & s_{wf} & 1
\end{bmatrix}
\]

As the coffee production chain is organized in a similar hierarchical way this restriction will also be applied to our model. The economic reasoning for such identification follows from the fact that we do not expect retail prices to have effect on the foreign and wholesale prices in the current period and, similarly, foreign price to have an impact on the wholesale price in the current period. One can justify this reasoning on two grounds. First, the market becomes smaller as we move from wholesale to foreign, and then foreign to retail market. The wholesale coffee market
caters to the coffee manufacturers/processors who supply to all the coffee importing countries of the world, whereas a retail market refers to only one of those importing countries. Nonetheless, one may argue that shocks from a large importing country could potentially affect the wholesale market. However, note that the restriction only restrains the contemporaneous effect, thus allowing feedback in a backward direction with a one-period or more lag.

The second reason arises if we think about the nature of the shocks expected to originate from the retail market. The retail markets which we model are all located in open economies, which reflect competitive market structures and allow for imports at minimal or no tariff rate. Therefore, the supply shocks, if any, from these markets are expected to be small. On the demand side, coffee demand is expected to be stable. Therefore, we would expect shocks of small magnitude from smaller market would not have contemporaneous effect on the upstream larger markets.

The Error Correction Model

Granger and Newbold (1994) showed that a regression model with non-stationary variables might result in the estimation of ‘spurious regression’. If the variables are integrated of order one $I(1)$ the first difference de-trends the series. If the $I(1)$ variables are not cointegrated, it is preferable to estimate VAR on first differences rather than on levels (Enders, 2004). However, if the $I(1)$ variables are cointegrated, then estimating a VAR in first differences without the inclusion of a cointegrating relation leads to misspecification error. Misspecification error is the result of the exclusion of long run equilibrium relationships among the variables. If this error is present then the resulting coefficient estimates, inferences and innovation accounting are not representative of the true process (Enders, 2004). Therefore, it is important to check for the existence of the cointegrating relationship among the variables included in the VAR model.

Although there are a number of alternative approaches to testing for cointegration Johansen’s maximum likelihood approach (MLA) was used in this study for a number for reasons. First, it has the advantage of being able to estimate and test multiple cointegrating relations. Second, we can test for the restricted version of the cointegrating vectors and the speed of adjustment. In addition to this, a comparative study by Gonzalo (1989) on five alternative methods of finding long run relationship found that the Johansen’s method provides the least biased and most symmetrically distributed coefficient estimates. This finding was robust to different distributional assumptions.

The model in equation (2) can alternatively be written as an error correction model (ECM).

$$\Delta x_t = a + \Pi_0 x_{t-1} + \sum_{i=1}^{p-1} \Pi_i \Delta x_{t-i} + e_t$$

where $\Delta x_t = x_t - x_{t-1}$, $\Pi_0 = -(I - \sum_{j=1}^{n} A_j)$ and $\Pi_i = -\sum_{j=i+1}^{p} A_j$. $I$ is a (3 X 3) identity matrix.

In equation (3) $\Delta x_t$ is stationary if $\Pi_0 x_{t-1} + \sum_{i=1}^{p-1} \Pi_i \Delta x_{t-i}$ is stationary. This implies that, $\Pi_0 x_{t-1}$, the linear combination of the variables (in levels) must be stationary. The rank of $\Pi_0$ is equal to the number of independent cointegrating vectors. If rank ($\Pi_0$)=0, then equation (3) is a VAR model in first differences. Alternatively, if the rank of $\Pi_0$ is n, then all variables are stationary. In our case, as n equals 2, there is a further possibility that $\Pi$ is of rank 1. In this case
we would have a single cointegrating vector and the expression $\prod_0 - x_{t-1}$ would be the error correction term.

Following Johansen, we define two matrices $\alpha$ and $\beta$, each of dimension $(n \times r)$, where $r$ is the rank of $\Pi_0$ such that $\Pi_0 = \alpha \beta'$. Here $\beta$ is the matrix of cointegrating parameters and $\alpha$ is the weight of each cointegrating vector in the respective equation. $\alpha$ is commonly referred to as the speed of adjustment parameters. The vector $\beta x_{t-1}$ denotes the cointegrating relation and, therefore, when it exists is stationary.

Johansen (1988) proposed two tests for estimating the number of cointegrating vectors, commonly referred to as $\lambda_{\text{trace}}(r)$ and $\lambda_{\text{max}}(r)$. The $\lambda_{\text{trace}}(r)$ tests the null hypothesis that the number of distinct cointegrating vectors is less than or equal to $r$ against a general alternative. The $\lambda_{\text{max}}(r)$ statistics test the null hypothesis that the number of cointegrating vectors is $r$ against the alternative of $r+1$ cointegrating vectors. The critical values tabulated by Johansen and Juselius (1990) have been used for these tests.

Using Johansen’s MLA one can test for the cointegrating relation and estimate the error correction model simultaneously. Therefore, before applying the MLA one has to decide on the inclusion of exogenous variables and choose the appropriate lag lengths for all the variables. The results of the tests can be quite sensitive to the lag length. The tests are also sensitive to the inclusion of the deterministic terms. In our case, we included an intercept term in the cointegrating vector. The drift term is not included because we do not expect that the first differences of the variables will have any trend (positive or negative). As for the intercept term in the cointegrating relation, it is a common practice to include it unless there is a priori reason against its inclusion.

**Lag length selection**

The lag length selection is an important step as the test results can be sensitive to the chosen lag length. Enders (2004) states that the most common procedure is based on the estimation of vector autoregression on levels. There are a number of methods, such as Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), Hannan-Quinn (HQ), Likelihood Ratio test (LR), Final Prediction Error (FPE) which can be used to test for appropriate lag length. The selection criteria mentioned above provide different ways of weighing improvements in the explanatory power against the loss of degrees of freedom. The results from these tests can be used for cointegration analysis and, consequently, for the error correction model. All three methods were used in this study.

We start with a lag length of 13 months based on an a priori notion that one year is a sufficiently long time to capture the system’s dynamics. The model was then estimated with lag lengths of 12 months, and subsequently estimated by reducing the lag length by one month until a lag length of one was reached. The lag lengths chosen by these three criteria were rather small considering the fact that the data is monthly (Table 9). Among these criteria, LR test has the highest lag length. However, we chose to estimate the base model with the lag lengths selected by the AIC.\textsuperscript{15} In

\textsuperscript{15} The above selection criteria penalize loss of degrees of freedom due to inclusion of an additional variable against improvement in the explanatory power. The fact that SBC penalizes more from degrees of freedom loss than AIC results in AIC suggesting more lag lengths than SBC. In order to guard against omitted variable bias, this may tend one to choose lag lengths suggested by AIC criteria. But note that there is a cost to that. Lutkepohl (1990) suggested that a very high lag length in VAR specification may result in
order to check for the robustness of our findings, we conducted sensitivity analysis with lag
lengths selected by other criterion.

**Exogenous variables**

The farm sector is considered to be exogenous to the system and, therefore, farm prices are
included as exogenous variables in the equations. Our initial analysis shows that in most cases
wholesale and retail prices do not Granger cause farm prices. Like many other agricultural
commodities, coffee bean prices tend to be more sensitive to supply than demand factors. One of
the major influences on prices is the weather conditions that prevail when crops are growing.
According to one estimate, the global demand for coffee is relatively stable, growing by around
10 per cent per annum during 2000-04. So if there is a feedback effect from consumer demand for
the final product to the upstream stages of production that feedback will be captured in the
wholesale sector through changes in the prices which, in turn, will influence retail prices.

The first difference of the country specific consumer price index was included for all items (CPI)
in the retail equation of the models. Table 3 shows the ratios of whole sale to retail prices of the
sixteen countries studied. These figures indicate that a substantial portion of the cost of processed
coffee accrues from sources other than coffee beans. Among others, these costs include
manufacturing, distribution, storing and advertising costs. The problem lies in the fact that coffee
manufacturing, from roasted coffee to different varieties available in supermarket shelves, may
take place in different parts of the world. Therefore, the CPI of the importing country is unlikely
to capture the variation of all the costs. However, it can be expected that CPI can provide a crude
measure of the costs (such as manufacturing, distribution, advertising) incurred in that particular
importing country.

Peltzman mentions that the CPI and the Producer Price Index (PPI) summarize the impact of
economy wide nominal demand and cost changes. Considering the impracticability of searching
and including the list of control variables for each of the hundreds of markets he analyzed,
Peltzman included current and lagged changes of the log of CPI and PPI in his equations. In our
case, the country specific CPI appears to be a good measure of cost and demand. Figure 2 shows
the nominal monthly retail prices for the period between 1976:01 and 2004:12 and figure 4 shows
the real prices for each of these countries obtained by deflating nominal prices by the respective
CPIs. The theories of spatial competition suggest that variation of prices of similar goods/close
substitutes should have similar patterns. Although the nominal prices of each of the countries
have similarities, particularly if we look at the peaks and the troughs, the similarities become
even more apparent when we deflate the nominal prices by the respective CPIs. This indicates
that a substantial portion of the price is determined by real factors, such as cost and demand
shifters, of each of the countries rather than nominal factors. The correlation coefficients of real
prices with each other are higher than those of nominal prices (Tables 5 & 6).

**Seasonal Dummies**

In addition to the above variables, we included seasonal dummies in each of the equations.
However, our preliminary analysis shows that the seasonal dummies, monthly or quarterly, do not
have any significant impact on either the wholesale or the retail equations. Therefore, weighing
against the loss of degrees of freedom resulting from their inclusion, we decided to drop the
seasonal dummies altogether from the base model.

imprecise estimates of the coefficients. In our case, given that we have monthly data, the lag length is not
large.
**Cointegration tests**

Cointegration tests were conducted for the 16 countries in a three-variable setting (wholesale, foreign and retail prices). Table 9 reports the $\lambda_{\text{trace}}(r)$ and $\lambda_{\text{max}}(r)$ statistics for $r=0$, $r\leq1$ and $r\leq1$, and their significance levels. The results based on $\lambda_{\text{trace}}(r)$ statistics indicate that the null of no cointegration ($r=0$) can not be rejected only in Japan. The null of no cointegration can be rejected for the other countries. Similar conclusion can be drawn using the $\lambda_{\text{max}}(r)$ statistics. In terms of the number of cointegrating vectors, the $\lambda_{\text{trace}}(r)$ points to one vector for Austria, Denmark, France, Norway, Spain, UK and the USA. The equations of the other countries (except Japan) have two cointegrating vectors. Table 13 reports the cointegrating vectors and the adjustment coefficients, denoted $\beta'$ and $\alpha$ in a common notation, for the eight countries where Johansen’s test indicated the presence of cointegrating relations.

Insert table 9 here.

Table 10 reports the adjustment coefficients, denoted by $\alpha$ in a common notation, for the 15 countries where Johansen’s test indicated the presence of cointegrating relations. The $\alpha$ coefficients measure the degree to which the variable in question adjusts to the deviation from long run equilibrium relationship. The first cointegrating equation is normalized with respect to retail the equations and the second, where applicable, is normalized with respect to the foreign price equations. Therefore, for a retail equation, which is our primary interest, we would expect the speed of adjustment corresponding to the first cointegrating equation to have a negative sign. In table 10, the $\alpha_{11}$ coefficients refer to the speed of adjustment corresponding to the first cointegrating equation. It shows that the speed of adjustment have the expected sign in thirteen countries. The signs are positive in Italy and the USA, however they are not significant according to chi-square tests at 5% significance level.

If the null hypothesis that $\alpha$ equals zero can not be rejected, then this would indicate that the disequilibrium in the long run relationship does not feed back onto the associated variable. If this is the case, we can exclude the error correction term from that equation. The $\alpha_{11}$ coefficients are found to be significant in 8 countries; Bellux, Finland, France, Netherlands, Portugal, Spain, Sweden and Switzerland. The magnitudes of adjustment are found to be quite high in Bellux, Finland, the Netherlands and Sweden. They are -12.7, -9.6, -14.4 and -13.2 per cent, respectively. For the sake of interpretation, for example, in the case of Bellux, the magnitude of adjustment of -0.127 indicates that in each month the retail price adjusts by 12.7 per cent of the disequilibrium in the long run relationship. In France, the adjustment is very low. The adjustments are between 4 and 5 per cent in Portugal, Spain and Switzerland.

Insert table 10 here.

**V. The Model Results**

The cumulative response functions for the base models of the sixteen countries are shown in figures 6 and 7. The response functions in figure 6 trace the dynamic impact of retail prices to one per cent change in costs originating from the wholesale sector. In this case the magnitude of the response is interpreted as the elasticity of the retail price with respect to wholesale input price The response functions in figure 7 show the dynamic impact of the same retail prices to a one per cent change in the price of a large coffee producing country. Here, the magnitude of the response can be interpreted as the elasticity of the retail price with respect to foreign price. Figure 6 shows that in nine out of sixteen cases prices respond to upstream cost changes and, in seven cases, prices
exhibit complete rigidity. One the other hand, figure 7 shows that prices of all the countries respond, almost in a similar way, to a foreign price shock.

In this analysis retail prices were found to respond to input cost changes in nine out the sixteen countries. These countries included Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden, UK and the USA. We will label these countries ‘responding’ countries in the following discussion. A consistent finding across responding countries was found with respect to periods taken for price adjustment after the cost shock was initiated. In seven out of the nine responding countries, price adjustment was found to take place over around two quarters. In the case of Germany, the adjustment process was found to be relatively fast, with an adjustment lags of less than one quarter. On the other hand, in France the adjustment process is relatively slow for the retail price, continuing for around five quarters.

The magnitude of retail price adjustment was found to vary between 0.15 and 0.50 per cent. As mentioned above, the magnitude can be interpreted as the elasticity of the retail price with respect to wholesale cost shocks. The magnitude was found to be the highest in France, the Netherlands, Norway and the USA, at around 0.50 per cent. In other words, in these three countries, a one per cent change in the cost results in around 0.50 per cent change in the price. On the other hand, the smallest magnitudes were found in Germany and UK, at only 0.15 and 0.20 per cent, respectively. In the other three responding countries, Belgium, Denmark and Sweden, prices were found to adjust by 0.25, 0.30 and 0.35 per cent, respectively.

It may be of interest to compare the proportion of cost change to the retail price and the magnitude of the price change. If they are equal, it indicates that the cost changes have passed through to the consumers through a proportional increase in retail prices. Table 18 shows that the proportion of costs and the magnitude of price change are similar in Belgium, Denmark, France and the Netherlands. Whereas in the other responding countries such as Germany, Norway, Sweden, UK and the USA, cost and retail prices changes are not similar. However, it should be mentioned the proportions have decreased consistently for all countries over the sample period, although the rate at which they have declined varies across the countries.

When the confidence intervals of the responses include zero then a country is said to exhibit complete price rigidity in response to a cost shock. This was found to be the case for seven countries including Austria, Finland, Italy, Japan, Portugal, Spain and Switzerland. Therefore, we conclude that in these seven countries prices do not respond to cost shocks. This finding implies that the firms located ‘downstream’ in the distributional channel absorb all of the wholesale cost changes.

In order to assess how the shocks of the large foreign markets pass through to the domestic market, we included ‘foreign prices’ in the models. An example of a foreign shock is an inflationary pressure in a large coffee market and we would like to trace the dynamic impact of price changes in the large foreign market on the domestic market. As discussed before, the foreign price is obtained from taking the weighted average of the US and German retail prices. The cumulative response function in the figure 7 shows the dynamic response of the domestic retail market to one per cent change in prices in the foreign market. In the models for the US and Germany, the equations for foreign price refer to German and US prices, respectively.

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16 Dutta et al. (2002) interpreted the price as rigid when the confidence interval included zero.
Figure 7 shows that the impacts of a foreign market shock to domestic prices across countries are quite similar. The average magnitude of the immediate impact is around 0.28 per cent in response to a one per cent shock (standard deviation is 0.05). After the immediate impact, for most countries, transmission occurs within a period of two quarters. It should be noted that similar response period was found for the responding countries with respect to the cost shocks. The average magnitude of adjustment at the end of two quarters is 0.51 with a standard deviation of 0.14. The similarity in the impact, both in terms of immediate impact and the adjustment process over time, is evidence of how well the markets are integrated.

In order to check for the robustness of the results, we estimated the models for each country in the following ways: (1) various sample periods; (2) different selections of lag lengths; and (3) exclusion of some exogenous variable(s). In total the model was estimated/specifed in 13 different ways. The impulse response functions from the estimated models are provided in appendix figures 1-8. Each of these figures (16 of them) is for one country and displays thirteen different impulse responses for that country under different model specifications. The top panel shows the impulse responses for cost shocks and the bottom panel shows the impulse responses foreign shock. The diagram (a) in each figure is the response function obtained from the base model, reproduced here from figures 6 and 7 for the purpose of comparison. The response functions of diagrams (b)-(g) relate to different sample periods. The diagrams (h)-(j) are the response functions estimated under different selections of lag lengths. The last set of diagrams (k)-(n) are the impulse response functions from the models estimated to check for the significance of exogenous variables.

The sample period for the base model is 1976:1-2004:12, the periods for which the models have been estimated are 1981:1-2004:12, 1986:1-2004:12, 1989:7-2004:12, 1976:1-1989:6, 1976:1-1994:12 and 1976:1-1999:12. The diagram (b) depicts the impulse response for the sample period 1981:1-2004:12, thus excluding the first five years from the sample period of the base model. The estimates and resulting impulse response appear to be similar to the base model. Note that the first three tests exclude the observations from the beginning of the sample period; 5 years, 10 years and around 14 years, respectively. A comparison of the results with the base model and other sample period models indicate that the response of retail prices to cost changes have not changed over the years. The next three diagrams, (e)-(g), exclude observations from the end of the sample periods. The similarity of the results for both the cost and foreign shocks reinforces the fact that the model results are insensitive to the selection of sample periods.

In order to check whether the model results are sensitive to the number of lags included, we estimated the models for each country with different lag specifications. Table 17 shows the number of lag lengths chosen by different selection criterion. The base models were estimated with the lag lengths selected by the AIC criteria. In the sensitivity analysis, the models were estimated for the whole sample period with the number of lag lengths selected by the BIC criteria and the LR test.17 The general conclusion is that, with the exception of few cases, changes in the lag lengths do not lead to a qualitatively different response in retail prices.

With respect to impact of cost shocks, if we compare the base models with the models estimated using BIC criterion, then in four countries, Denmark, France, Netherlands and Norway, there are some (minor/major) changes in the magnitude of the response. Comparison of the base models with the corresponding LR models show that in the case of Finland and the Netherlands, the

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17 Note that the number of lag lengths selected by the HQ and FPE are in most cases the same as those of BIC and AIC.
responses are quite different. Using the LR criterion the impulse responses for Finland and the Netherlands show that price does respond to cost changes, although in the base case prices were unresponsive. In the case of the Netherlands, the response becomes more persistent; with adjustment occurring over five quarters and the magnitude increasing from 0.5 to 0.75 per cent. The response to cost shock between the AIC and LR models appear to be similar for other countries.

The responses to foreign shock using AIC and BIC models are similar. The only difference can be seen in the case of France, where the BIC model where prices are found to be unresponsive unlike that of AIC. However, for some countries, LR produces different results than the base models. The responses seem to become more persistent and reach higher magnitudes for Bellux, Italy, Portugal and Switzerland. For a number of other countries, including Finland, Japan, Netherlands, Spain, UK and USA, the confidence intervals of the responses become very large. The estimated standard deviations from the coefficients of the additional lags are very large, leading to wide confidence intervals.

The last set of sensitivity analysis involves exogenous variables. The exogenous variables included in the models are farm prices, consumer price indices and the average of the retail prices of the sixteen countries. Although individually each of these variables is not significant in all the countries, they are found to be jointly significant. This is evident in diagram (m), figures 8-15. When all three exogenous variables are excluded from the model impulse responses appear to be different from the corresponding base models. In most cases, the magnitudes of the adjustment appear to be higher relative to the base model where all the exogenous variables are included. This indicates that the exogenous variables explain part of the variation of the domestic retail prices.

While retail prices of seven countries exhibit complete rigidity, nine countries respond to cost shocks. There exists a strong evidence that the process of adjustment continues for two quarters, although the magnitude of adjustment varies from between 0.15 and 0.50 per cent. With respect to foreign shocks, the retail prices in all 16 countries are found to be responsive. There are similarities in the way prices of different countries respond to foreign shocks; typically, there is an immediate impact with price, adjustment continuing for another two quarters. The average magnitude of price adjustment at the end of the second quarter is approximately 0.5 per cent.

6. Discussions

Price rigidity is estimated for the retail sectors of the coffee markets in sixteen countries with respect to shocks originating from the wholesale sector and the large coffee consuming countries. We estimated three aspects of price rigidity: (1) the speed of price change; (2) the magnitude of price change; and (3) the time path of adjustment. The following discussion will be limited to the first two aspects. However, in term of policy implications, all three aspects are important.
The speed at which the retail prices adjust to wholesale cost shocks depends on the actions of the agents located at the downstream stages of the wholesale market. These agents establish the link between the two markets. Examples of few of the agents include exporters, traders, manufacturers and transporters. The actions of each of these agents are governed by many factors such as the market structure, technology and the nature they are linked with each other. For example, it can be expected that if there are few agents and each of them operates under competitive environment, cost changes will pass on to the retail sector relatively quickly.

In this analysis, it was found that, among the responding countries, generally it takes approximately two quarters (six months) for a wholesale cost shock to pass on to the retail sector. For comparison purposes, it should be mentioned that Dutta et al. (2002) found a lag of four to six weeks (approximately one and a half month) in the response of retail prices of orange juice concentrates in the US market to wholesale cost shocks. Blinder et al. (1994) found an average lag of three to four months in their firm survey study on wide range of products in the US. Fabiani et al. (2005) reports that “…an adjustment process of one quarter in macro models for France, Luxembourg, Austria and Portugal and of two or more quarters for Spain seems to be justified on the grounds of these findings” (p.29). The above comparison indicates that in general price rigidity in the coffee markets are higher than in many other markets of the sixteen countries studied.

There are a number of reasons for the delay in transmission of cost changes to the next stage of the distributional channel. Fabiani et al. (2005) found that in the euro area the most important explanations for rigid prices are provided by the customer market models (nominal and implicit contracts). The nominal contract theory says that the agents may prefer to establish explicit contracts that set prices in advance in order to establish a long term relationship (Fisher, 1977; Taylor, 1980). Even if there is no explicit contract, a implicit contract may deter the agents to change the price (Hicks, 1974; Okun, 1981; Schultze, 1985; Nakamura and Steinsson, 2006).

Blinder et al. (1998) found that two of the most important reasons for the existence of price rigidity in the US are explained by coordination failure and firms’ pursuance of cost based pricing. Coordination failure occurs because each firm unsure of its competitors’ action waits for the competitor to take the lead. The idea of cost based pricing is that the firms change prices only when costs of input changes. Blanchard (1983) showed that in a chain of production, the accumulation of lags in the arrival of information in each stage may cause substantial delays in responding to cost changes.

Another popular explanation is provided by different variants of menu cost models. Menu cost models say that there are costs associated with changing prices and if that cost is higher than the benefit accrued from it, then the firm will deter from changing the price (Barro, 1972; Danzinger, 1983; Sheshinski and Weis, 1977, 1983; and Golosov and Lucus, 2006). Alternatively, uncertainty about the nature of the shock, whether it is transitory or permanent, may also be responsible for delayed response.

The firm survey study shows that within the same industry there were variations in the way the firms responded regarding the relevance of a particular price rigidity theory (Blinder et al., 1998; Apel et al., 2005; Hall et al., 1997; Fabiani et al., 2005). Thus, at any point of time a certain number of firms will change their prices while prices will remain fixed for some other firms. This

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18 Coffee beans have to pass through the hand of a large number of middlemen, other than big players like manufacturers and importers, before they reach supermarket shelves (The Fairtrade Foundation, 2002).
causes the impact of shocks on the whole market to be distributed over time. The overall rankings found from these surveys in the euro area, Sweden, UK and the US are provided in the appendix table 2.

The study shows that the magnitude of the price adjustment varies among the countries. Among the responding countries, the maximum and minimum magnitudes are 0.5 and 0.15 per cent, respectively, and four countries adjust in the vicinity of 0.5 per cent. A number of reasons can be put forward for these variations. The market demand of the final good may vary among the countries resulting in a varying ability of the firms or retailers to pass on the cost change to the consumers; the higher the price elasticity of demand, the less is the change in the price. Alternatively, firms in the short run may make substitution in the use of inputs to relatively cheaper inputs of production.

Carlton (1989) argues that market may clear along dimensions other than price such as delivery lags, product quality, selling effort and level of services. For example, instead of raising price, firms may respond by reducing selling efforts, the quality of the product and service. These measures contribute towards absorbing increased costs. Carlton suggests that an optimal mixing of all instruments clear the market. In the survey study of Blinder et al., the idea of ‘non-price competition’ ranked third among the twelve competing theories. However, it ranked poorly (8th) in the Fabiani et al. euro area study.

In addition, firms may choose to adjust inventory rather than prices (Reagan, 1982; Blinder, 1982). It implies that with a positive cost shock, prices would rise less than it would be if the firms do not have inventories to vary. Another reason for the existence of price rigidity may be due the belief that certain prices have psychological significance to the consumers and firms may not want to exceed that barrier. However, Kashyap (1995) found only limited evidence supporting this theory. Among the survey studies, the idea was appreciated in UK (Hall et al., 1997, 2000), but ranked poorly for the US and Sweden (Blinder et al., 1998; Apel et al. 2005).

Market structure can play an important role in determining firms’ reaction to cost changes. Dornbusch (1987) showed that the impact of cost shock is larger the more competitive the market. He formulated an oligopolistic market structure where the degree of competition was measured by the markup of price over marginal cost and the source of cost shock was exogenous movements of exchange rate. He showed that “[t]he market structure – import share and concentration – are the key parameters that explain the outcome [the magnitude of price change]” (p.97). The industrial organization literature tells us that market concentration is the hallmark of administered prices.

Viqueira (1991) using individual price data of a wide range of products in Mexico found that the more concentrated industries tend to have lower frequency of price adjustment. Viqueira’s finding was found to be robust to different measures of market concentration. Hannan and Berger (1991) examined the deposit rates of different banks and found that banks in more concentrated market exhibit greater price rigidity. As mentioned above, Dutta et al. found that the retail prices of orange juice concentrates in the US are flexible, adjusting relatively quickly, often within 4-6 weeks. They report that the markets for orange juice concentrates are highly competitive both at the manufacturing and retail levels. McCorriston and Sheldon (1996) showed that both the number of vertical stages and the degree of imperfect competition at any specific stage can negatively affect the degree of tariff pass-through.

In the Fabiani et al. study, one of the key findings which appeared as a stylized fact is that “[m]ark-up (constant or variable) pricing is the dominant price setting practice adopted by firms
in euro area. The lower the level of competition, the frequently used this method is” (p.15). The study found that in each country mark-up pricing dominates to any other pricing rules and, as a whole of the euro area, 54 per cent of the firms follow mark-up pricing rule\(^{19}\). The variable mark-up rule is found to have taken the lead in the countries where questionnaires allowed them to make a distinction between constant and variable mark-up pricing rules. The second important pricing rule is found to be “price setting according to competitors’ price” (27 per cent). Another related finding consistent across countries is the existence of negative relationship between the share of firms following the mark-up rule and the degree of competition.

The survey results prompted Fabiani et al. to suggest that “models with monopolistic competition, like New Keynesian models, may be a better description for most goods and service markets than those that assume perfect competition”\(^{p.5}\). They argue that mark-up, which under general conditions is a feature of imperfectly competitive market structure, provides firms some room for not adjusting the price in variation to costs. Therefore, price rigidities can occur unlike in a perfectly competitive market where price equals marginal cost.\(^{20}\) Rotemberg and Woodford (1994) provide an overview of different models with exogenously and endogenously determined time-varying mark-ups and their implications on macroeconomics. In the case of the US market, Blinder et al. found that the idea of coordination failure offered the most attractive explanations for price rigidity for the majority of the firms. This implies that most of the US firms set price according to competitors’ price. This suggests that price rigidity may be expected to be lower in US than in the euro area. Alvarez et al. (2005) reports that price durations in the euro area is significantly longer than in the US.

The coffee markets in the countries studies are found to be highly concentrated. Table 13 shows the concentration ratios CR1 and CR4, where CR1 and CR4 refer to the share of the market captured by the largest firm (one firm) and the largest four firms, respectively. The CR4 was found to be as high as 90.7 per cent in Portugal in 2004 with the largest firm capturing 68 per cent of the market. The lowest concentration ratios were found in US, the CR1 and CR2 being 18.8 per cent and 42.5 per cent, respectively. According to Scherer (1990), a CR4 of above 40 per cent is an indication of firms’ being enjoying market power. The CR4 in all the countries are above 40 per cent indicating that coffee manufacturers or roasters are enjoying moderate to extreme degrees of market power in those countries\(^{21}\).

7. Conclusions
Much of the empirical studies of price rigidity examined variations within or across product groups in a single location. In recent years, the literature has seen a number of cross country studies within the euro area covering a wide range of products. This study, on the other hand, is specific to only one product (coffee). The product is subject to high degree of international trade and, therefore, the markets among the countries are expected to be well integrated. The study used dynamic econometric models and examined price rigidity by analyzing the transmission of shocks to the retail sector. This way of examining price rigidity, among different alternative

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\(^{19}\) The results of Austria and Luxembourg were not reported.

\(^{20}\) Although price rigidity is more likely in less competitive markets, in the extreme case of very high cost of adjustment, even highly competitive firms may fail to adjust to small input cost changes.

\(^{21}\) The coffee markets for the whole world in its different distributional channels are very concentrated. According to The Fairtrade Foundation (2002), the industry is dominated by four multinational companies: Proctor and Gamble, Philip Morris, Sara Lee and Nestle account for 40 per cent of the worldwide retail sales. Similarly, the 40 per cent of the export of coffee beans is controlled by six multinational firms.
measures, is particularly useful for macroeconomic purposes. A cross country comparison was
drawn among 16 countries including the countries in the euro area and the US. The finding of this
study can be generalized to some other products, such as products having similar market features.

Almost half of the countries do not respond to input cost shocks. A finding consistent among the
responding countries was that the adjustment took place over around two quarters, although the
magnitude of adjustment varies. With respect to foreign shocks, there is an immediate impact.
After the immediate impact, for most countries, the transmission occurs within a period of two
quarters. Therefore, in both cases, a general conclusion can be drawn that the price adjustment
occurs within two quarters after the shock is imposed. However, the evidence suggests that, in
general, retail prices are more responsive to foreign shocks than to cost shocks. Not only do more
countries respond to foreign shocks when compared to cost shocks, but also the average
magnitude of adjustment is higher for foreign shocks than cost shocks.
Figure 1: Composite index and its four component indices for wholesale prices

Figure 2: Nominal retail prices of 16 different countries (in US cents)
Figure 3: Ratios of wholesale to retail prices in 16 countries

Figure 4: Real retail prices of 16 different countries
Figure 5: Accumulated impulse response of retail prices to one per cent cost shock

Figure 6: Accumulated impulse response of retail prices to one per cent shock from a large coffee consuming country
Table 1: Ratio of ICO wholesale composite index to nominal retail prices

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<td>0.40 (0.13)</td>
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<td>0.22 (0.07)</td>
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<td>0.23 (0.08)</td>
<td>0.32 (0.13)</td>
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<td>0.17 (0.05)</td>
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<td>0.24 (0.10)</td>
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Figures in the parenthesis are the estimated standard errors.

Table 2: Augmented Dickey Fuller test on the log of nominal price series

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<td></td>
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Note: * and ** denote that the estimated characteristics roots are significantly different from unity at 5 and 1 per cent, respectively.
Table 3: Perron’s test for unit root with structural change on nominal farm and whole sale prices of coffee beans and nominal retail prices of coffee

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<td>0.00</td>
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Note: * and ** denote that the estimated characteristics roots are significantly different from unity at 5 and 1 per cent, respectively. The critical values are obtained from Perron (1989). + indicates the process having unit root with one time change at the point of break.
Table 4: Cointegration test results

<table>
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<th>$\lambda_{trace}$</th>
<th>$\lambda_{max}$</th>
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<td>5.34*</td>
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** significant at 1% level; * significant at 5% level; significance level is determined using MacKinnon-Haug-Michelis (1999) distribution.

Table 5: The coefficients of the speed of adjustment

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<th>Wholesale equation</th>
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<td>1st coint.</td>
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<td>($\alpha_{11}$)</td>
<td>($\alpha_{12}$)</td>
<td>($\alpha_{21}$)</td>
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<td>0.034</td>
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<td>Switzerland</td>
<td>-0.044*</td>
<td>0.023*</td>
<td>0.032</td>
</tr>
<tr>
<td>UK</td>
<td>-0.006</td>
<td>n.a</td>
<td>0.030*</td>
</tr>
<tr>
<td>USA</td>
<td>0.010</td>
<td>n.a</td>
<td>0.102*</td>
</tr>
</tbody>
</table>

* significant at 5% per cent level. chi-square test is used to determine the significance level n.a refers to not applicable
### Table 6: Lengths of lag selected by different selection criteria

<table>
<thead>
<tr>
<th>Country</th>
<th>AIC</th>
<th>BIC</th>
<th>HQ</th>
<th>LR</th>
<th>FPE</th>
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<tbody>
<tr>
<td>Austria</td>
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<td>1</td>
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<tr>
<td>Bellux</td>
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<td>6</td>
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<td>1</td>
<td>12</td>
<td>2</td>
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<td>1</td>
</tr>
<tr>
<td>Japan</td>
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<td>1</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Netherlands</td>
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<td>1</td>
<td>2</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Norway</td>
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<td>2</td>
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<td>5</td>
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</tr>
<tr>
<td>Switzerland</td>
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<td>1</td>
<td>8</td>
<td>1</td>
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<tr>
<td>UK</td>
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<td>1</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>USA</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: AIC: Akaike Information Criteria; BIC: Bayesian Information Criteria; HQ: Hannan-Quinn Criteria; LR: Likelihood Ratio Test; FPE: Final Prediction Error

### Table 7: Concentration ratios in coffee markets, 2001 and 2004

<table>
<thead>
<tr>
<th>Country</th>
<th>One-firm conc. (CR1)</th>
<th>Four-firms conc.(CR4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>25.5</td>
<td>27.1</td>
</tr>
<tr>
<td>Belgium</td>
<td>40.0</td>
<td>41.6</td>
</tr>
<tr>
<td>Denmark</td>
<td>29.2</td>
<td>30.6</td>
</tr>
<tr>
<td>Finland</td>
<td>49.4</td>
<td>47.9</td>
</tr>
<tr>
<td>France</td>
<td>45.7</td>
<td>44.6</td>
</tr>
<tr>
<td>Germany</td>
<td>22.0</td>
<td>21.6</td>
</tr>
<tr>
<td>Italy</td>
<td>42.4</td>
<td>44.0</td>
</tr>
<tr>
<td>Japan</td>
<td>42.2</td>
<td>40.6</td>
</tr>
<tr>
<td>Netherlands</td>
<td>58.7</td>
<td>59.8</td>
</tr>
<tr>
<td>Norway</td>
<td>29.6</td>
<td>31.5</td>
</tr>
<tr>
<td>Portugal</td>
<td>66.0</td>
<td>68.0</td>
</tr>
<tr>
<td>Spain</td>
<td>31.7</td>
<td>30.0</td>
</tr>
<tr>
<td>Sweden</td>
<td>41.1</td>
<td>41.1</td>
</tr>
<tr>
<td>Switzerland</td>
<td>32.2</td>
<td>32.6</td>
</tr>
<tr>
<td>UK</td>
<td>42.8</td>
<td>39.7</td>
</tr>
<tr>
<td>USA</td>
<td>18.9</td>
<td>18.8</td>
</tr>
</tbody>
</table>

Source: Authors’ own calculation from the data obtained from the Global Market Information Database published by Euromonitor Plc.
References:


Estimating price rigidity in coffee markets: A cross country comparison

Ph.D candidate: Iqbal Syed
Supervisor: Prof. Kevin Fox
UNSW
Why are empirical measures of price rigidity important?

• Better understanding of monetary policy transmission

• Better judgement of different measures of underlying inflation

• Limited number of empirical work
  – “Unfortunately, this program [the standard programs of scientific research in economics] has been singularly unsuccessful in the area of wage-price stickiness.” (Blinder et al. 1998)
Definition

• Price rigidity is “[o]ften nothing more than that prices adjust less rapidly than Walrasian market-clearing prices”. (Blinder, 1998)

• “Price rigidity is said to occur when prices do not vary in response to fluctuations in costs and demand.” (Carlton and Perloff, 1994)

• A number of theories based on the firms’ optimization rule provide explanations for the existence of price rigidity
Empirical measures of price rigidity

• Frequency of price change in a given period (Kashyap, 1995; Nakamura & Steinsson, 2006)
• Probability of price change due to cost or demand changes (Cecchetti, 1986; Campbell & Eden, 2004)
• The number of periods price response lags behind the shock (Pelzman, 2000; Dutta et al, 2002)
  – Focus of this paper
  – Vector error correction model
Countries

- Austria
- Belgium & Luxembourg
- Denmark
- Finland
- France
- Germany
- Italy
- Japan
- Netherlands
- Norway
- Portugal
- Spain
- Sweden
- Switzerland
- UK
- USA
Market Integration and coffee markets

• Economic and commercial policies promote market integration
• Coffee has high tradable inputs
• Market demand similar
• Points to the fact that coffee market should be integrated
• Market structure plays an important role – heterogeneity in price rigidity
Data

- Sources: ICO & OECD
- Endogenous variables
  - Wholesale coffee bean price (weighted average of different varieties of coffee beans) – 1 series
  - Domestic retail prices of 16 countries – 16 series
- Exogenous variables
  - Brazilian variety farmgate coffee bean prices-1 series
  - CPI All Items - 16 series
  - Monthly average exchange rates for home currency in terms of US currency – 15 series
Wholesale prices

Figure 1: Composite Index and its four component indices for wholesale prices
Nominal retail prices of 16 different countries (in US cents)
Correlation coefficients of nominal retail prices
(see appendix table 3 for all countries)

<table>
<thead>
<tr>
<th>Country</th>
<th>Norway</th>
<th>Spain</th>
<th>UK</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>0.45</td>
<td>0.68</td>
<td>0.26</td>
<td>0.36</td>
</tr>
<tr>
<td>Bellux</td>
<td>0.92</td>
<td>0.48</td>
<td>0.53</td>
<td>0.79</td>
</tr>
<tr>
<td>Finland</td>
<td>0.83</td>
<td>0.83</td>
<td>0.34</td>
<td>0.65</td>
</tr>
<tr>
<td>France</td>
<td>0.68</td>
<td>0.72</td>
<td>-0.14*</td>
<td>0.27</td>
</tr>
<tr>
<td>Germany</td>
<td>0.78</td>
<td>0.82</td>
<td>0.17</td>
<td>0.50</td>
</tr>
<tr>
<td>Japan</td>
<td>0.33</td>
<td>0.50</td>
<td>0.54</td>
<td>0.59</td>
</tr>
</tbody>
</table>
## Import of major coffee bean importing countries as a percentage of total coffee bean import of the world in 2004

<table>
<thead>
<tr>
<th>Country</th>
<th>%</th>
<th>Cum %</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>25.24</td>
<td>25.24</td>
</tr>
<tr>
<td>Germany</td>
<td>19.10</td>
<td>44.34</td>
</tr>
<tr>
<td>Japan</td>
<td>7.86</td>
<td>52.20</td>
</tr>
<tr>
<td>Italy</td>
<td>7.65</td>
<td>59.85</td>
</tr>
<tr>
<td>France</td>
<td>6.65</td>
<td>66.50</td>
</tr>
<tr>
<td>Spain</td>
<td>4.60</td>
<td>71.10</td>
</tr>
<tr>
<td>Belgium</td>
<td>4.47</td>
<td>75.57</td>
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<tr>
<td>UK</td>
<td>3.72</td>
<td>79.29</td>
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<tr>
<td>Netherlands</td>
<td>3.59</td>
<td>82.88</td>
</tr>
<tr>
<td>Poland</td>
<td>3.11</td>
<td>85.99</td>
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<tr>
<td>--------------</td>
<td>--------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Austria</td>
<td>0.44</td>
<td>0.22</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.45</td>
<td>0.28</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.38</td>
<td>0.24</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.42</td>
<td>0.21</td>
</tr>
<tr>
<td>UK</td>
<td>0.20</td>
<td>0.10</td>
</tr>
<tr>
<td>USA</td>
<td>0.55</td>
<td>0.32</td>
</tr>
</tbody>
</table>
Model

\( r = \text{domestic retail}, \ f = \text{large country retail} \)

and \( w = \text{wholesale price of beans} \)

\( \Delta x = \text{first difference of the log of nominal price} \)

\[
\Delta x_t^r = g_1 (\text{LOP}_\text{eq}) + g_2 (\sum_{i=1}^{p} \Delta x_{t-i}^r, \sum_{i=1}^{p} \Delta x_{t-i}^f, \sum_{i=1}^{p} \Delta x_{t-i}^w)
\]

\[
+ g_3 (\sum_{i=1}^{q_1} z_{1t-i}, \sum_{i=1}^{q_2} z_{2t-i}, \sum_{i=1}^{q_3} z_{3t-i}) + g_4 (\text{season}_\text{quarterly}) + \text{shocks}
\]

Similarly for \( \Delta x_t^f, \Delta x_t^w \)

Law of one price (LOP) equation:

\[
x_t^r = \delta_1 + \delta_2 e_t + \delta_3 x_t^f + \nu_t
\]
Identification

\[ \Delta x_t^w = E_t(\Delta x_t^w) + \varepsilon_t^w + \alpha_{12}\varepsilon_t^f + \alpha_{13}\varepsilon_t^r \]

\[ \Delta x_t^f = E_t(\Delta x_t^f) + \alpha_{21}\varepsilon_t^w + \varepsilon_t^f + \alpha_{23}\varepsilon_t^r \]

\[ \Delta x_t^r = E_t(\Delta x_t^r) + \alpha_{31}\varepsilon_t^w + \alpha_{32}\varepsilon_t^f + \varepsilon_t^r \]

After recursive identification

\[ \Delta x_t^w = E_t(\Delta x_t^w) + \varepsilon_t^w \]

\[ \Delta x_t^f = E_t(\Delta x_t^f) + \alpha_{21}\varepsilon_t^w + \varepsilon_t^f \]

\[ \Delta x_t^r = E_t(\Delta x_t^r) + \alpha_{31}\varepsilon_t^w + \alpha_{32}\varepsilon_t^f + \varepsilon_t^r \]
Estimation related issues

• Unit root or near unit root process- modeled first difference of the logs
• Lag selection: AIC for the base model, other selection criteria in sensitivity analysis
• Speed of adjustment of the LOP
• Coefficient restrictions – seemingly unrelated regression model
• Weak exogeneity tests to reduce the equations in the VAR model
Sensitivity Analysis

- Various sample periods (6 different sample periods for each model)
- Lag lengths selected by BIC, HQ, LR and FPE (see table 6, p.26 for the lag lengths)
- Exclusion of exogenous variables – jointly significant
- Results are found to be robust to sample sizes and number of lags
Similar models

• McCarthy (1999)
  – CPI, PPI and aggregated import prices

• Peltzman (2000)
  – Component indexes of CPI and PPI in US market
Impulse response function

• Traces the time path of the impact of a variable to external shock

• Primary interests
  – response of domestic retail price to wholesale cost shock
  – response of domestic retail price to foreign shock

• Results are studied in terms of accumulated impulse response to a 1% cost and large country shock
Accumulated impulse response of retail prices to one per cent cost shock

Accumulated Impulse Response

Accumulated Impulse

Accumulated Impulse

Accumulated Impulse

Accumulated Impulse

Accumulated Impulse

Accumulated Impulse

Accumulated Impulse

Accumulated Impulse

Accumulated Impulse

Accumulated Impulse

Accumulated Impulse
Results: Cost shocks

• Prices are completely rigid in 7 countries

• In other 9 countries
  – Period of adjustment is two quarters (7 countries)
  – Magnitude ranges between 0.15 and 0.50 %

• Heterogeneity in the price response
Price rigidity theories

- Customer market model (Fabiani et al.; 2005)
- Coordination failure (Blinder et al.; 1998)
- Lags in information arrival (Blanchard; 1987)
- Menu cost models (Sheshinski & Weiss, 1977, 1983)
- Market demand and input substitution
- Non-price competition (Carlton; 1989)
- Adjustment of inventories
- Psychological pricing points
Price rigidity and market structure

Market structure

- Imperfect market structure allows firms to adopt mark-up pricing rules
- The more competitive the market, the larger is the impact of cost shocks (Dornbusch, 1987)
- The more concentrated industries have lower frequency of price adjustment (Viqueira, 1991)
- The retail prices of orange juice concentrates are very flexible because of high degree of competition (Dutta et al., 2002)
Concentration in coffee markets
(see table 7, p. 28 for all countries)

<table>
<thead>
<tr>
<th>Country</th>
<th>CR1</th>
<th>CR2</th>
<th>CR4</th>
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</thead>
<tbody>
<tr>
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<td>27.1</td>
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<td>71.7</td>
</tr>
<tr>
<td>Belgium</td>
<td>41.6</td>
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<td>30.6</td>
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<td>76.3</td>
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<td>UK</td>
<td>39.7</td>
<td>67.6</td>
<td>70.5</td>
</tr>
<tr>
<td>USA</td>
<td>18.8</td>
<td>39.1</td>
<td>42.5</td>
</tr>
</tbody>
</table>
Market structure in the euro area

• “Mark-up (constant and variable) pricing is the dominant price setting practice adopted by firms in euro area” (Fabiani et al., 2005, p.15).
• 54 % of the firms follow mark-up pricing rule
• Variable mark-up rule dominates
• “Models with monopolistic competition, like New Keynesian models, may be a better description for most goods and service markets than those that assume perfect competition” (Fabiani et al., 2005, p.5)
Accumulated impulse response of retail prices to one per cent large country shock
Summary result

- Immediate impact 0.28% to 1% shock
- Prices adjust for around 2 quarters
- Average magnitude of adjustment in 0.5%
- Destination specific mark-up adjustment depends on the market demand
- Pricing to market or degree of price discrimination is similar across countries
Contribution and broader implications

• Heterogeneity in the degree of price rigidity in coffee markets across countries
• Price rigidity theories and market structure
• Microeconomic issues – macroeconomic implications
• Monetary policy implication for the countries in the European Monetary Union (EMU)
• A given shock may have differential impact in different regions of an economy
• Similar work for different markets
Residual Analysis: USA

DLCOM Residuals

DLUS Residuals
Residual Analysis: Austria

DLCOM Residuals

DLAU Residuals