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A Model of Farm Price Levelling when Variability comes from Export Demand, Illustrated with Coffee Marketing Margin Data in Papua New Guinea, 1999-2010*

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ABSTRACT

In this paper a new model of short-term price levelling behaviour is introduced, for the case of variability arising from demand-side factors rather than supply-side factors. The key components are the direction of the information flow in the market, and the ability of value chain participants to adjust their demand for and supply of market services. The model is illustrated using data from the Papua New Guinea coffee industry. Almost all PNG coffee is exported to a wide range of countries. The industry has a competitive marketing structure with many active producers and buyers of various sizes. There is keen competition for the limited supply of coffee, but inefficiency in the pricing mechanism has long been a concern to many producers in the industry, in particular the smallholder coffee producers. They argue that increases in world coffee prices have not been fully passed on to growers, with exporters and processors able to hold their buying prices stable in the face of rising world market prices. In this study marketing margin analysis is used to investigate and test hypotheses related to price levelling, and in addition, the influence of marketing costs and throughput, on the aggregate industry margin, and the exporting margin and processing margin components. Average monthly price data over the period January 1999 to December 2010 are used. Using simple regression models, at the whole chain level short-run price levelling is confirmed and both aggregate costs and total volume of exports are significant determinants of the size of the margin. Short-run price levelling is also confirmed at both the exporting and processing stages, but in the preferred models, while throughput is an important determinant of exporter and processing margins, costs have a significant but negative effect on margins. Partial adjustment processes are important in determining margins at all stages.

***Keywords**: Coffee, prices and margins, Papua New Guinea, price levelling.*

* This paper is based on a Master of Economics thesis submitted to the University of New England in 2012 by Charles Dambui and supervised by Stuart Mounter and Garry Griffith (Dambui, 2012). An earlier version of a paper from the thesis was presented at the 9th International European Forum on System Dynamics and Innovation in Food Networks, held in Igls, Austria, in February 2015 (Dambui et al., 2015). This current version differs from the earlier paper because the model specification has been changed and the price data employed have been slightly revised. The authors thank Euan Fleming, John Freebairn, Bill Malcolm and Journal referees for comments on earlier drafts.

1 Introduction

The coffee industry is the second largest contributor to Papua New Guinea's (PNG) agricultural exports in terms of foreign exchange earnings, averaging 1.1 million bags (66,000 metric tons) valued at Kina 300 million per year over the past 10 years (BPNG, various issues)[2]. The industry is an important provider of employment and income with approximately one-third of PNG's population engaged in its production, processing and sale. PNG green bean coffee is exported to around 50 countries, the main destinations being Germany, United States, Australia and Japan (CIC, 1999-2009). Although almost all its coffee is exported, PNG is a price taker in the international market, supplying just over one per cent of the world's coffee.

There are a large number of coffee processors and exporters who compete for the limited quantities of beans available each year. The intense competition for the limited supply of coffee often leads to price wars whereby the costs of marketing at times becomes irrelevant in setting the farm or factory-door (fdr) price, leading to concerns about pricing efficiency in the processing and export of coffee. One concern has been that accurate transmission of changes in supply and demand conditions from one market level to another is inhibited. World coffee prices increased in the period under study, but coffee growers and marketing groups noted that changes in supply and demand conditions on the world market are not fully reflected in the prices paid at the different domestic marketing levels. That is, the exporters and processors are practising price levelling to stabilise the fdr prices.

Previous studies of these issues in the context of the PNG coffee industry are limited. Smith (1991) observed that the short-run margins tend to rise and fall with the world price of coffee, and Tautea (1992) suggested that price levelling was practiced by some firms while others employed a fixed mark-up pricing strategy, but both of those studies are now quite dated. These concerns led the Coffee Industry Corporation Ltd (CIC) to request a re-investigation of the pricing behaviour of exporters and processors and to quantitatively examine if evidence of price levelling exists.

The main aims of this paper are to illustrate the new model of price levelling behaviour, and in so doing, to determine whether PNG coffee exporters and processors are holding buying prices stable in the face of rising world market prices and whether exporter and processor margins are related to the costs of marketing services and to the volume of coffee traded.

2 The PNG Coffee Industry

About 75 per cent of coffee output in PNG comes from smallholders, with larger 'block' holders (up to 50ha) and the plantation sector or 'estates' (around 300ha) accounting for up to 15 per cent and 10 per cent, respectively. Most smallholders produce parchment coffee, where ripe coffee cherries are pulped, washed and dried, using hand pulpers and sun drying. This form of dried bean is traded between farmers, sold to the roadside buyers or directly to the factory. The decision on which buyer to sell to depends on the proximity to the factory, transportation, the fdr price offered and the quantity of parchment held in-stock. The prices obtained at factories differ from those offered at the roadside. The latter prices are usually lower but vary from buyer to buyer, depending on which dry-mill factory purchases the parchment.

Similarly, block holder coffee is sold to the dry processing mill for a fdr price; almost all of these producers have contracts with processors with a guaranteed price margin depending on the reliability and quality of the parchment produced.

Approximately one-third of the plantation sector of the industry is vertically integrated through to the export sector. Plantations that have wet and dry processing facilities sell directly to exporters and thus obtain a delivered-in-store (dis) price. Parchment coffee produced in the estates and blocks is usually converted to green bean and sold directly to exporters or dry-mill processors, receiving the dis price. The exporters negotiate with traders/buyers overseas to deliver a specific type, quality and quantity of green bean coffee at a plus or minus differential on the net free-on-board (fob) price. The exporters usually sort, regrade, repackage and export the green bean coffee in 60-kg hessian bags.

Partly integrated exporters are companies that not only are involved in export but also have some processing facilities including owning or having a share in some plantations. The partly integrated export companies account for 57 per cent of exports. Companies that have their operations integrated right through to the point of exports are called plantation-based exporters. While they are small in terms of total coffee exported (7 per cent of exports), they export about one third of the plantation produced coffee. A more detailed description of these trading arrangements can be found in Dambui et al. (2015) and in Huffaker et al. (2021).

[2]The exchange rate at September 2021 was approximately 1.00 $AUD = 2.58 PGK.

In summary, coffee can be traded as cherries, parchment and green bean, depending on the economic agents involved in the transaction and the facilities available. Cherries are normally handled at the farm level and often traded with wet-mill processors who are vertically integrated with the farmers. Parchment and green bean are mostly traded between farmers, dry-mill processors and to a lesser extent, exporters. The green bean is frequently traded between dry-mill processors, exporters and traders/buyers overseas. Because of the different levels of processing, common yield factors have to be applied to ensure price quotes at the different market levels are comparable (see Appendix).

PNG grows Arabica coffee predominately, and this is exported under numerous green bean grades. In this paper, aggregate volume and value data across all grades is used in the analysis.

3 Trends in Coffee Price and Margins

Smith (1992) observed that the total industry margin tends to rise and fall with the price of coffee. Figure 1 shows the monthly indicator price published by the International Coffee Organisation (ICO) and the New York (NYC) and London monthly futures prices from January 1999 to December 2010. The analysis is restricted to this period since a unique set of cost data was collected for the thesis and unfortunately it has not been possible to update that data set. In this paper, aggregate data are used. In a companion paper (Dambui et al., 2023) price levelling and price averaging across grades of coffee is investigated, as in the original thesis.

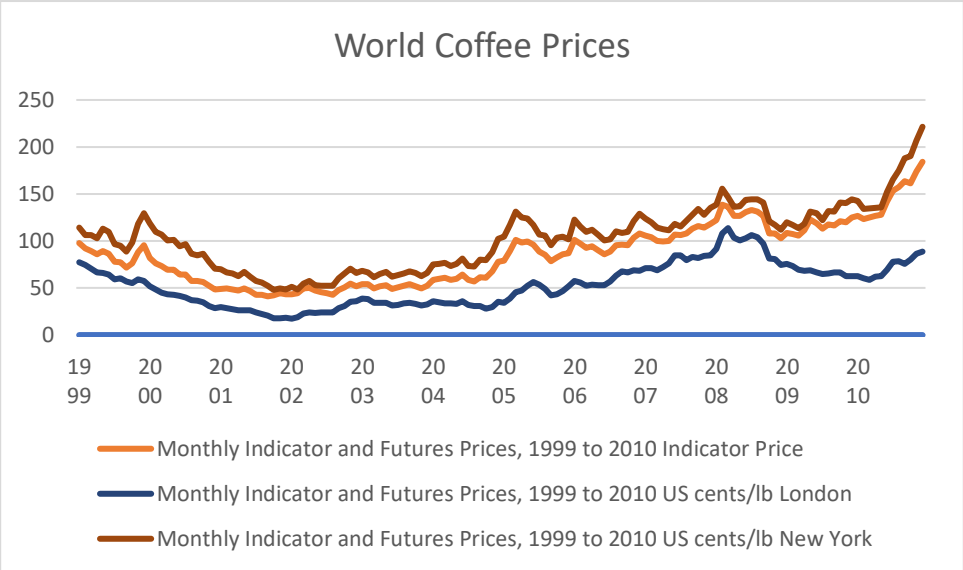

Figure 1. Monthly average world coffee prices, 1999-2010 (US cents/lb GBE)
(Source: CIC statistical database)

The NYC price is primarily for Arabica coffee, the London price is primarily for Robusta coffee, and the ICO price is a mix of types. Over the period observed, the lowest prices were recorded in late 2001. From late 2004 to December 2010 the world coffee price trended upwards, reaching US 221.51 cents/lb and US 184.26 cents/lb for NYC and ICO, respectively. The upward trend in coffee prices during 2010 was supported by favourable market fundamentals, and investors moving into commodities including coffee post the 2008 Global Financial Crisis were also thought to be responsible. The NYC and ICO world price series show a very close relationship over this data period, as does the London price up until early 2009 when it diverged from the other prices. The PNG fob prices are typically priced off the NYC price quotes.

PNG domestic coffee prices mirrored the movement in world coffee prices, as shown in Figure 2. The upward trend in world market prices from 2004 was maintained for domestic prices, including the sharp rise in 2009-2010. One reason why prices held up in the domestic market is because PNG quality coffee attracts a premium over the world market prices. While the relationships between the domestic prices are close, they are not as close as are the world price quotes, and there is some evidence of short-term divergences in direction, and indications that the margins between the prices are of different magnitudes from each other and over time.

These observations are confirmed by examining the relevant correlation coefficients (Table 1).

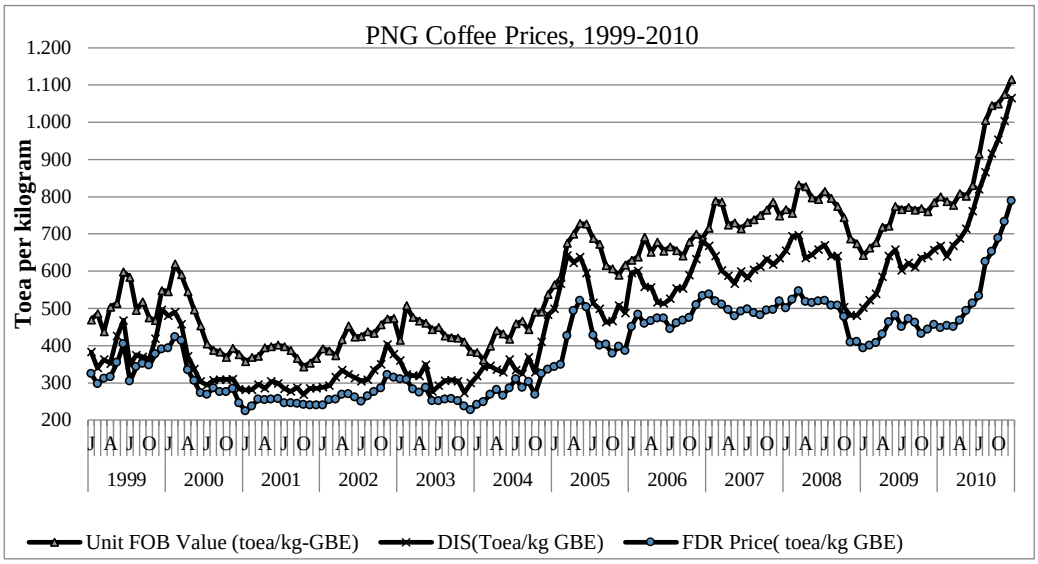

Figure 2. Monthly average PNG coffee prices, 1999-2010 (toea/kg GBE)
(Source: CIC statistical database)

Table 1.
Correlation coefficients between world and PNG coffee prices and margins, 1999-2010 (toea/kg GBE)

	Fob price	Dis price	Fdr price	Exporter margin	Processor margin	Total margin
NYC price	0.942	0.978	0.953	-0.017	0.868	0.779
Fob price		0.971	0.965	0.751	0.828	0.902
Dis price			0.970	0.011	0.900	0.821
Fdr price				0.109	0.761	0.757
Exporter margin					-0.169	0.445
Processor margin						0.807

Over the period January 1999-December 2010, the four price series were all positively and closely associated with each other and with the processor and total margins, although the degree of association was weaker at the farm level (Table 1). The exporter margin was negatively associated with the processor margin and with the world price, and only weakly positively related to the dis and fdr prices. There is certainly not a smooth transmission of price changes from one market level to another. This hints at price levelling behaviour.

4 A New Approach to Price Levelling

The concept of price levelling has a history in the agricultural economics literature of around 60 years. It was developed to explain behaviour by food retailers when setting prices charged to customers: price levelling is said to occur when the retailer takes a smaller margin when farm prices are high, and a higher margin when farm prices are low.[3] In his seminal paper, Parish (1967) explained the broad rationale as a desire to keep prices to customers relatively stable so they would continue to visit their shop and purchase approximately the same quantities as usual (it is easier to lose customers than win them), to maintain economies of size and to minimise the costs of changing prices and informing customers of these price changes.

[3] A companion paper (Dambui et al., 2023) investigates price levelling and the related concept of price averaging across the main grades of coffee.

There is extensive historical empirical evidence of price levelling behaviour in a number of fresh meat and vegetable markets. Parish (1967, p.187) quoted evidence presented to government enquiries and empirical evidence from published research during the 1960s that price levelling existed in retail meat markets in at least three different countries (the United Kingdom, the United States and Australia), while a number of more recent investigations have confirmed the presence of this practice in both Australian meat markets and fruit and vegetable markets (Griffith, 1974; Griffith, Green, and Duff, 1991; Griffith, Jamandre, and Piggott, 1992; Griffith and Piggott, 1994). All empirical evidence finds that price levelling is a short-term phenomena – over one or a few months at most – and that retail prices revert to trends in farm prices over the longer term.

Parish (1967) mentions in passing that if the cause of price fluctuations are shifts in demand, with retail price levelling, the same price impacts are expected but that 'quantities marketed are less stable than they would be in the absence of levelling' (p.194). But every other published paper found in a formal search that mentions 'price levelling' does so in the context of a domestic consumer market, where any variability that influences input prices comes from the supply side of the market.

This situation is shown in Figure 3. At equilibrium the farm supply curve is $S_{f0,}$ the derived retail supply curve is S_{r0}, the retail demand curve is D_{r0} and the derived farm level demand curve is D_{f0}. It is assumed that S_{f0} shifts to the left to S_{f1}, perhaps as a result of an adverse weather event. The equilibrium quantity is reduced from Q_0 to Q_1, the equilibrium farm price increases from P_{f0} to P_{f1} and the equilibrium retail price increases from P_{r0} to P_{r1}. With a typical upward sloping supply curve for market services, D_{f0} and D_{r0}, and S_{f0} and S_{r0}, diverge as quantity increases. Thus, P_{r1}-P_{r0} is smaller than P_{f1}-P_{f0}. Retail prices are more stable than farm prices in equilibrium.

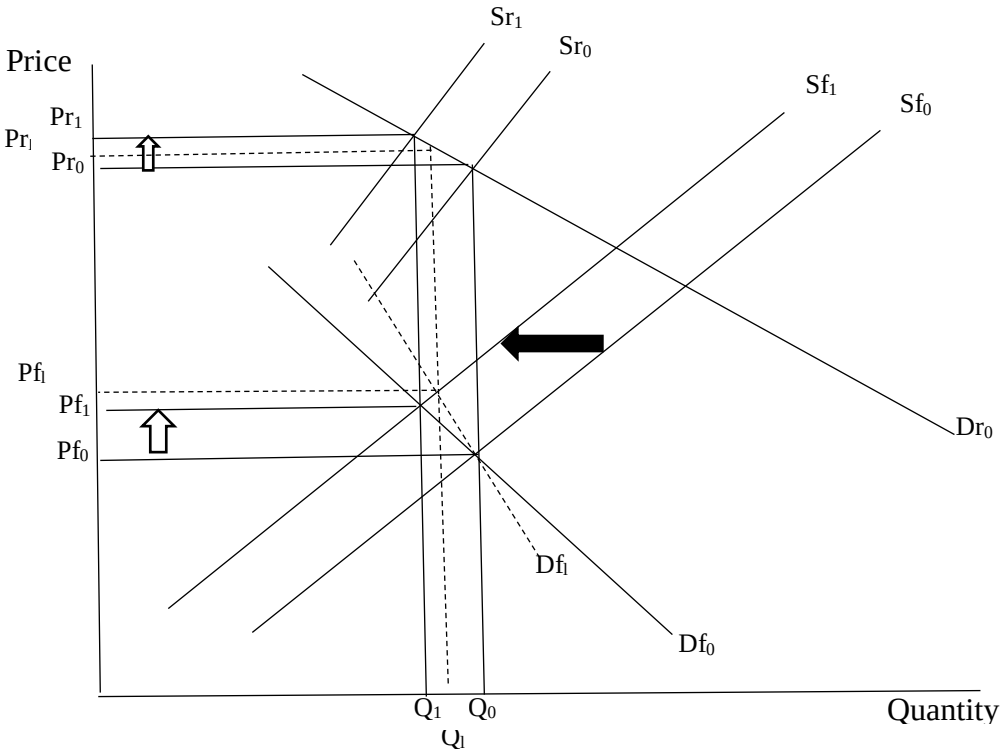

Figure 3. Retail price levelling, when the variability comes from supply

But price levelling is a short-term behaviour. The question is what is the behaviour change that results in even more stable retail prices? In his analysis, Parish (1967, p.193) explicitly states that retail demand is assumed not to shift, but derived demand does. Thus, it must be the supply of retail marketing services, that the retailer has some control over, that has to adjust. He also mentions (1967, p. 197) a retail butcher choosing to supply different bundles of attributes to customers, depending on the relative cost of the services versus the meat.

To achieve retail price levelling when supply contracts temporarily, retailers impose a supply of retail marketing services that is less price elastic, which has the effect (because of the direction of causality) of making the short-term derived demand curve D_{fl} more price inelastic. The demand curve D_{fl} rotates through the initial equilibrium point (basically replicating the left-hand side of Parish's Figure 1 on p. 193). This gives the familiar result that when farm prices rise (due to the assumed leftward shift in supply), with retail price levelling the farm-retail marketing margin contracts and retail

prices are more stable than they would be otherwise. Conversely, farm prices are more unstable than they would be otherwise.

If supply were to increase in the short run, rather than decrease, with retail price levelling behaviour in place (the right-hand side of Parish's Figure 1 on p. 193), the farm-retail marketing margin would expand and again retail prices would be more stable than they otherwise would be in equilibrium.

In this domestic market situation, the causal flow of information is that changes in the farm price cause changes in the retail price, and in empirical estimation it would be expected that with price levelling the size of the farm-retail marketing margin is negatively related to the farm price in the short term. However, the underlying longer term or equilibrium conditions still have to be taken into account. Hence a measure of the longer-term trend in prices, a measure of marketing cost to calibrate position in relation to the vertical axis, and a measure of throughput to calibrate position in relation to the horizontal axis, all have to be included in the model specification. A model of this type makes it possible to explain retail price levelling when farm supply is variable, and a model such as this is the basis for most of the available empirical research on price levelling.

However, there is also a substantial body of literature that focusses on the implications for agricultural producers, particularly developing country exporters, of instability in prices received and farm incomes due to world market disruptions, and of mechanisms to reduce this instability. Some of these mechanisms are government stabilisation policies, but many are implemented by value chain participants. In relation to the world coffee market, many of the references cited in Ghoshray and Mohan (2021) are relevant, some of which focus on smallholder coffee producers in PNG. None of these studies formally uses the concept of price levelling to explain this type of private sector stabilisation behaviour, even though coffee producers have noted that this behaviour has been occurring and that they were not receiving in full the flow on benefits of rises in world market prices (it is not clear which modelling approach the previous studies on the PNG coffee market employed).

This situation is shown in Figure 4. Again, the equilibrium curves are D_{x0} and D_{f0}, and S_{f0} and S_{x0}, the equilibrium prices are P_{x0} to P_{f0} and the equilibrium quantity is Q_0. Now it is assumed that the export demand curve D_{x0} has shifted to the left to D_{x1}, perhaps as a result of a recession in an importing region. The derived demand curve shifts from $D_{f0\ to}$ D_{f1}. The equilibrium quantity is reduced from Q_0 to Q_1, the equilibrium export price decreases from P_{x0} to P_{x1} and the equilibrium farm price decreases from P_{f0} to P_{f1}. With an assumed upward sloping supply curve for market services, D_{x0} and D_{f0}, and S_{f0} and S_{x0}, diverge as quantity increases. Thus, in this case, P_{x1}-P_{x0} is larger than P_{f1}-P_{f0}. Farm prices are more stable than export prices in equilibrium.

But again, to achieve short term price levelling, processors/exporters must be able to impose a less elastic supply of marketing services, rotated through the initial equilibrium point. This has the effect (because of the direction of causality) of making the short-term derived supply curve S_{xl} more price inelastic. This gives a new farm price levelling result that when export prices fall (due to the assumed inward shift in export demand), the farm-export marketing margin contracts, farm prices are more stable than they would be otherwise and, to the extent possible, fob prices are more unstable than they would be otherwise.

If demand were to increase in the short run, with farm price levelling in place, the farm-export marketing margin would expand and again farm prices would be more stable than they would be otherwise in equilibrium.

In this export market situation, the causal flow of information is that changes in the export price cause changes in the farm price, and in empirical estimation it would be expected with farm price levelling that the size of the farm-export marketing margin would be positively related to the export price in the short term. As in the retail price levelling case, the underlying longer term or equilibrium conditions must be accounted for, so included are measures of longer-term trends in prices, marketing cost to calibrate position in relation to the vertical axis, and throughput to calibrate position in relation to the horizontal axis.

In this paper, the typical retail price levelling model specification found in the literature, as a response to variability on the supply side (Figure 3), is adapted to the opposite situation, that is variability on the demand side, as faced by PNG smallholder coffee producers (Figure 4), and the data are examined to test whether this model helps explain pricing outcomes in this market.

5 Model Specification and Data Sources

This study draws on the methods used in estimating short run pricing behaviour in other industries (Griffith, 1974; Griffith, Green, an Duff, 1991; Griffith an Piggott, 1994), and in some of the empirical studies reviewed by Wohlgenant (2001). But as noted above, the assumed direction of price transmission is reversed. Given the data available, the exporter margin, processor margin and total margin are considered separately. The exporter is assumed to respond to changes in the fob price, and the processor is assumed to respond to changes in the dis price. These causal assumptions

are tested. And, as mentioned previously, aggregate monthly volume data and average monthly price data are used, across all grades and all markets.

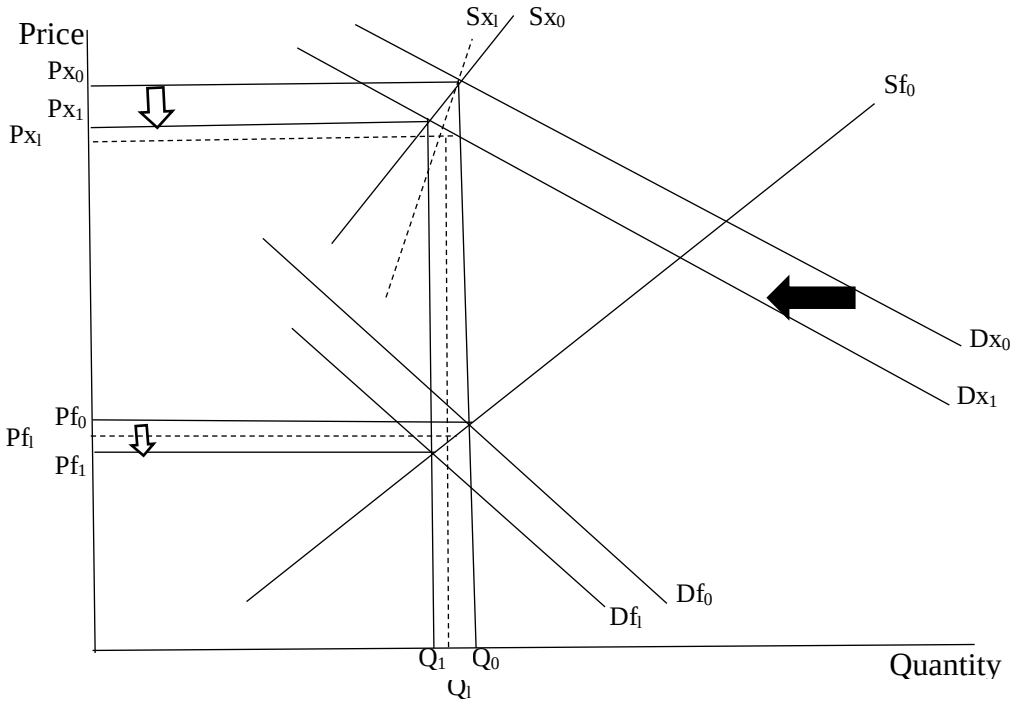

Figure 4. Farm price levelling, when the variability comes from demand

The three sets of estimated equations are as follows[4]:

Export margin: EM = f (FOB, LFOB, EMC, Q, LEM)

Processor margin: PM = f (DIS, LDIS, PMC, Q, LPM)

Total margin: TM = f (FOB, LFOB, TMC, Q, LTM)

Where for each month, EM = calculated exporter margin; PM = calculated processor margin; TM = calculated total margin; FOB = recorded fob price; DIS = recorded dis price; EMC = calculated export marketing costs; PMC = calculated processor marketing costs; TMC = calculated total marketing costs; Q = recorded quantity exported; all in the current month; and L = 1 period lag.

All the basic price data came from the records kept by the Economics Unit of the PNG Coffee Industry Corporation Ltd. (the CIC). All prices and margins are converted into real toea per kilogram using the PNG CPI. All prices are average prices across all grades and all markets. The variables used in the estimated equations are defined in Appendix 2.

Apart from the direction of causality, it is also necessary to assume a time–lag between the purchases of the coffee from the grower to the point of export. During the season, the coffee can be turned over very quickly, but most exporters go through some re-grading and re-bagging before export. Much of the coffee business is done "back to back" which means that the purchase contract with the processor is made as close to the sale contract as possible. However many sales contracts are made in advance, some at a fixed price. Therefore, there can be both a lag and a lead between the average monthly export price and the grower's price. Since the data is collated and analyzed on a monthly basis, it is reasonable for various actors along the supply chain to have some desired price margin in mind when developing and adjusting pricing practices as many of their costs could be regarded as fixed or near-fixed over this length of run. A lagged dependent variable is justified on the basis of partial adjustment behaviour of coffee marketers in a competitive PNG marketing system. This type of behaviour is characteristic of lagged responses by exporters and processors which

[4] Monthly dummy variables were included and tested for seasonality but based on the estimated F statistics and Likelihood Ratio tests, they were omitted from the final models. At most, two individual monthly dummy variables were significant in any estimated equation.

stipulate that the expected or predicted price margin is most likely to prevail when they sell or export their green bean coffee (Tautea, 1992). Incorporating a lagged dependent variable also has the advantage of compensating to some extent for autocorrelation, which is to be expected with long-time series of monthly observations (Marceau, 1967 cited from Griffith et al., 1991).

If exporters are holding their dis prices stable in the face of the rising world coffee prices (price levelling at the export level) and refusing to pass on price rises, then the variable FOB will have a positive coefficient indicating that when FOB prices increase the exporters margin expands in the short-term, while the variable LFOB is expected to have a negative coefficient as it represents the longer term adjustment of the margin to the trend in world prices. The coefficient on the dis variable in the processor margin would be expected to have similar signs. From theory, both marketing costs and throughput are expected to be positively related to marketing margins. However, it has been found previously that the marketing cost variables for PNG exporters and processors are often not significant given the inability of the PNG coffee industry to influence export prices (Tautea, 1992).

6 Results and Interpretation

6.1 Examining the data

Before estimating the three specified regression equations, the data are examined. First, basic descriptive statistics are computed for each of the major series. These are shown in Table 2. While the four individual price series, and the total margin, have similar relative variabilities, the exporter and processor margins individually have substantially greater levels of relative variability. Together with the information in Table 1, these statistics infer that the individual margins are being manipulated by processors and exporters to achieve a relatively stable farm price.

6.2 Causality tests

In setting up the margins model employed here, the assumption has been made that the direction of causality flows from the world price to the export price to the processor price to the farm price. That assumption is tested in Table 3, where Granger causality tests are reported, for different lag structures.

The complexities of price discovery in this value chain are reflected in the results that most prices are determined jointly in a Granger sense when tested using monthly data. See also the results presented in McConnell et al. (1996).

These results can be explained by the discussion in the Appendix describing the data series: for example

"… the exporter's margin which covers operational costs and profit. The margin depends on costs of operation, a target profit, as well as other factors such as a stock position, the level of competition between exporters, availability of supply, the suppliers' record and relationship with the exporter."

Further, the data used are an arithmetic average of the quotations offered by the exporters across different grades and destinations and are not weighted by the volume of trade. Finally,

"Much of the coffee business is done "back to back" which means that the purchase contract with the processor is made as close to the sale contract as possible. However, many sales contracts are made in advance, some at a fixed price. Therefore, there can be both a lag and a lead between the average monthly export price and the grower's price."

6.3 Trends in coffee margins

The trend in real margins (Figure 5) between 1999 and 2010 show a positive trend in total and processor margins and a negative trend in export margins. These trends add to the proposition that the increase in domestic coffee prices has had a positive impact on processor margins but a negative impact on the exporter margin (Tautea, 1992). The negative trend in the exporter margin may be due to the fact that supply of coffee in PNG is fixed or constant over time. When prices are high the export margin is squeezed because exporters have to pay higher prices to secure available supplies to fulfil shipment commitments.

The unavailability of data on individual exporters and processors in each province means the study could not statistically substantiate any evidence of non-competitive behaviour on an individual firm basis. However, there is anecdotal evidence to suggest that the coffee producers in PNG are responsive to price changes (fob and dis) and tend to adjust their marketing strategies to capitalise on price changes. Marketing margins are said to vary considerably from one province to another and between individual exporters and processors.

Table 2.
Descriptive statistics

	NYC price	Fob price	Dis price	Fdr price	Exporter margin	Processor margin	Total margin
Standard deviation	176.9	177.2	171.5	117.1	42.6	64.7	71.2
Mean	674.2	596.1	483.1	386.2	112.9	96.9	209.8
COV	0.26	0.30	0.36	0.30	0.38	0.67	0.34

Table 3.
Granger causality tests

	1 period lag		2 period lag		3 period lag	
	F stat[a]	LR stat[b]	F stat	LR stat	F stat	LR stat
World -> fob	63.97*	54.13*	40.38*	36.43*	21.63*	20.66*
Fob -> world	2.53	2.58	8.18*	8.17*	11.32*	11.19*
Fob -> dis	0.22	0.23	0.0001	0.0001	0.56	0.58
Dis -> fob	133.05*	96.03*	96.50*	75.29*	65.94*	55.40*
Dis -> fdr	48.43*	42.74*	62.75*	53.22*	66.42*	55.73*
Fdr -> dis	11.53*	11.40*	14.02*	13.74*	13.97*	13.69*

[a] 5% significance values are F(1,140)=3.91; F(2,138)=3.06; F(3,136)=2.68.
[b] 5% significance values are CHISQ(1)=3.84; CHISQ(2)= 5.99; CHISQ(3)=7.81.
* = Significant at 5%.

The above observation on the trends of market margins is consistent with the results reported by Smith (1991) and Tautea (1992). Smith (1991) observed that in the short-run, the total margins tend to rise and fall with price of coffee as indicated in Figure 2 and Figure 5. Tautea (1992) mentioned that due to high levels of competition the limited supply of coffee, marketing firms practice some combination of fixed and variable pricing behaviour including price levelling.

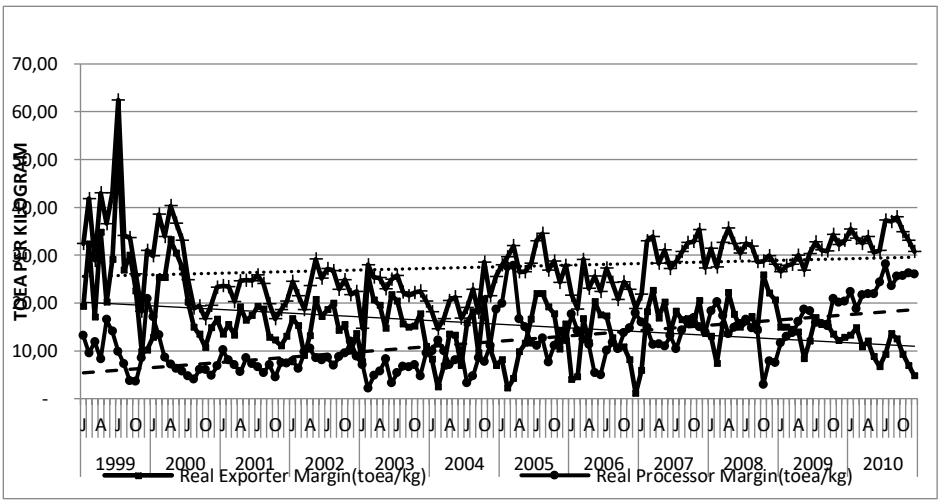

Figure 5. Real aggregate coffee margins, 1999-2010
(Source: CIC statistical database)

6.4 Unit root tests

Most econometric estimation techniques use the assumption that the time series being examined are stationary, that is "the mean and variance are constant over time and the covariance between two values from the series depends only on the length of time separating the two values and not on the actual time at which the variables are observed" (Hill et

al., 2001, p.335). If the series are non-stationary, spurious regressions may result, where significant relationships are found when there are none. High R^2 values together with low Durbin-Watson statistics are common indicators of non-stationarity.

The stationarity of a time series can be tested by using a unit root test. Here we use three procedures. First is the standard 'augmented Dickey-Fuller' (ADF) test which allows the addition of constant and trend variables. For the various series to be considered as stationary, the Dickey-Fuller tau statistic should be significantly different from zero. The other two procedures used were the Phillips-Perron (PP) test and the weighted-symmetric (WS) test. All testing procedures were undertaken but preference was given to the PP test as it is considered more robust with respect to heteroscedasticity and dependence of errors across time.

The results of applying these tests are shown in Appendix 3. Based on these results it can be concluded that the data series used in the analysis are stationary and that estimation can proceed without any further transformations being required.

6.5 Price levelling models

First, separate OLS econometric models are estimated for the exporter margin, the processor margin, and an aggregate of the two. This assumes that exporters and processors are making margin decisions independently, or that the errors in the exporter equation are uncorrelated with the errors in the processor equation.

As shown in Table 4, the equation for the total margin has a high R^2 indicating that the model accounts for a significant proportion of variation in that margin, and the Durbin Watson statistic is acceptable.

The margin is positively and significantly related to the current output price. When fob prices rise, the margin expands so that only a portion of the price increase is passed back to input prices. Price levelling is confirmed. However, the margin response is reversed in the next month, and most of the margin expansion is recouped. And because aggregate data are used, this price levelling behaviour holds across all grades of coffee, all types of products and all export destinations. Further, the aggregate of processing and exporting costs are positively and significantly related to the total margin, the level of exports has a positive and significant effect, and partial adjustment processes are found to be significant and positive.

When the component margins are examined, quite different effects are evident (Table 4). While the processor margin has a high adjusted R^2 above 90 per cent, the explanatory power of the exporter margin is much lower at only 38 per cent. Durbin Watson statistics are acceptable in both equations.

Table 4.
OLS results for the exporter, processor and total margins, 1999-2010

Variable	Exporter Margin		Processor Margin		Total Margin	
	coefficient	t-statistic	coefficient	t-statistic	coefficient	t-statistic
Constant	22.44	1.41	-34.24	-3.42	-21.51	-1.69
Current output price	0.495	4.11	0.520	13.54	0.596	9.54
Lagged output price	-0.448	-3.54	-0.462	-11.85	-0.501	-6.82
Cost index	-0.057	-1.47	0.056	3.92	0.025	1.74
Quantity traded	0.0002	2.45	-0.0000	-0.18	0.0001	2.16
Lagged dependent variable	0.681	6.57	0.685	13.72	0.638	8.64
Adj. R^2	0.38		0.94		0.90	
DW	1.84		2.01		1.89	
N	143		143		143	

Price levelling is confirmed in both equations. The margins are positively and significantly related to the current output prices. When fob or dis prices rise, the relevant margin expands so that only a portion of the price increase is passed back to input prices. As in the total margin, the margin response is reversed in the next month, and most of the margin expansion is recouped.

Processing costs are positively and significantly related to the processor margin but exporting costs are not related to the exporting margin. This result supports Tautea (1992) who noted that costs are unlikely to be a significant influence

on export prices. In other words, the impact of exporting costs (transportation, handling costs, customs and wharfage charges) on the variation of export margins may be confounded by other relevant costs such as certification and inspection costs, quality control, packaging and others which are not included in the cost index used.

Conversely, the level of exports has a positive and significant effect on the exporter margin but has no influence on the processor margin. Partial adjustment processes are found to be significant and positive in both margins. These results point to quite different and perhaps conflicting decision processes by processors and exporters, as hinted at in Tables 2 and 3 and Figure 5.

One reason might be the modelling approach used in Table 4 is not the best one. It was indicated above that a substantial proportion of PNG coffee is handled by partly or fully integrated businesses that are involved in exporting, processing and in some cases growing coffee. It is likely then, that in these businesses, decisions made about exporter margins are not independent of decisions made about processor margins. Thus, errors in the exporter model are likely correlated with errors in the processor model. Joint estimation using the seemingly unrelated regression (SUR) technique is indicated (Hill et al., 2001, pp.352-356). These results are shown in Table 5.

In the SUR models, the expected price levelling behaviour is again confirmed, with larger effects and stronger significance levels. Also confirmed is that partial adjustment processes are significant and positive in both margin equations.

The two variables where slightly different results are obtained from those in Table 4 are cost and throughput. The cost variable is now uniformly negative and significant, while the quantity traded variable is now uniformly positive and significant.

Table 5.
SUR results for the exporter and processor margins together, 1999-2010

Variable	**Exporter Margin**		**Processor Margin**	
	Coefficient	**t-statistic**	**coefficient**	**t-statistic**
Constant	27.62	1.90	19.26	0.783
Current output price	0.982	26.69	1.935	51.27
Lagged output price	-0.919	-20.28	-1.800	-33.99
Cost index	-0.129	-4.09	-0.118	-2.735
Quantity traded	0.0002	2.30	0.0002	1.974
Lagged dependent variable	0.912	23.56	0.641	11.22
Adj. R^2	0.35		0.69	
DW	1.63		1.72	
N	143		143	

7 Conclusions

The purpose of this study has been to develop and implement a new model for examining price levelling behaviour when the source of variability in the market arises from shifts in market demand curves, and then using data from the PNG coffee industry to use this model to test hypotheses of price levelling and the effect of costs and throughput on margins at different market levels in this industry. The study provides a more theoretical basis upon which the PNG Coffee Industry Corporation can better understand the marketing behaviour of the exporters and processors along the coffee supply chain.

The study confirms previous work by concluding that in the short-run the aggregate margin is positively and significantly related to the current output price. When fob prices rise, the margin expands so that only a portion of the price increase is passed back to prices to farmers. However, the margin response is reversed in the next month, and most of the margin expansion is recouped. Also, as expected, the aggregate of processing and exporting costs are positively and significantly related to the total margin, the level of exports has a positive and significant effect, and partial adjustment processes were found to be significant and positive.

Further, exporters and processors are separately practicing price levelling in the PNG coffee industry to stabilise delivered-in-store and factory-door prices. In the preferred SUR equations, the impact of costs is negative while the

volume of exports has a positive and significant effect on all margins. Finally, partial adjustment processes were found to be significant and positive in both component margin equations.

The analysis reported here has used aggregate data over the period 1999-2010 to test for price levelling and the impact of cost and throughput variables in the exporting and processing stages of the PNG coffee industry. The proposed model seems to work well in explaining value chain pricing behaviour over this time period. Updating the cost data to the recent past would be a very valuable addition. A companion paper will use data on the main grades of coffee to look at price levelling in a more disaggregated context, and to also consider price averaging across grades. There is always potential ways to improve the underlying data such as by incorporating international cost indices including shipping costs, taking a closer look at lag structures and comparing and testing alternate model specifications. Various other factors which influence pricing behaviour of the exporters and processors such as the extent of non-competitive behaviour should be considered in a future study.

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Appendix 1. Price Calculations and Standard Conversion Ratios

1 Calculating fob Prices

Exporters use New York and London terminal (futures) market prices to calculate their export (fob) prices. The procedure for calculating Arabica coffee prices is as follows:

- Determine relevant New York futures price quotation. Prices are quoted for 5 delivery months (March, May, July, September & December). The month you choose depends on the timing of possible shipment. The following can be used as a guide:

Shipment Month	Futures Delivery Month
January-March	March
March-May	May
May-July	July
July-September	September
September-December	December

- Add premium to or deduct discount from New York futures price. The premium or discount is called the *differential.* The *differential* is determined by the quality of coffee and the supply-demand situation among other factors. Plantation coffees (A & X grades) usually attract premiums while smallholder coffee (Y1 grade) is usually sold at a discount against the New York price. The price is expressed in US cents/pound.
- Multiply by 2.2046. The new price is expressed in US cents/kilogram (1 kg = 2.2046 pounds).
- Divide by the Kina to US dollar exchange rate.

The figure derived from the four steps is the exporter's fob price expressed in kina per kg. Exporters normally show fob price per grade on returns submitted to the Lae Export Office of the Coffee Industry Corporation.

2 Calculating Delivered-in-Store Prices

The exporter deducts a margin to cover operational costs as well as profit. This margin depends on the costs of operation, target profit, as well as other factors such as stock position, the level of competition between exporters, supply, the suppliers' record and relationship with the exporter etc.

The price obtained by deducting the exporter's margin is called the dis or delivered-in-stock price. It is the price the exporter pays to the processor. Up to this point, the prices are expressed as per kg of green bean.

3 Calculating Factory Door Prices

From the dis price, the processor deducts a margin to cover costs and profit. The resulting figure is converted to cater for weight losses between green bean and parchment. That is, the processor would have to convert the dis price to a parchment price by multiplying the figure with the average recovery rate. This is necessary because the processor will be paying a parchment price to growers. The parchment price offered by the registered factory is the price at the factory door. The average weight loss between parchment and green bean in PNG is between 20 and 40 %, depending on the quality of parchment and presence or absence of foreign matter such as sticks, stones, skin, etc. It also depends on the moisture content of parchment. The less dry the parchment, the greater the weight but the higher the weight loss in re-drying prior to processing.

4 Calculating Market Margins

Market margins are calculated based on the fob, dis and factory prices collected on a weekly basis by the economics section of the Coffee Industry Corporation Ltd.

Net fob price (cents/lb) = gross fob price – levy
Total Margin = net fob price – factory door price gbe[5]
Export Margin = net fob price – dis price
Processor Margin = dis price – factory door price gbe

5 Conversion Factors

Conversion Ratios as adopted by the PNG Coffee Industry Corporation

- Cherry to Green bean: multiply the net weight of the cherry by 0.16
- Cherry to Parchment: multiply the net weight of the cherry by 0.2
- Parchment to Green bean: multiply the net weight of the parchment by 0.75

Alternatively, the conversion ratios by kilograms;

- Cherry to Green bean: 6.25kg of cherry =1kg of GB
- Cherry to Parchment: 5kg of cherry =1kg of parchment
- Parchment to Green bean: 1.33 kg of parchment=1kg of green bean

Conversions accepted by ICO.

In accordance with internationally accepted practice, all quantity data represent bags of 60 kg net (132.276 lb) green coffee or the equivalent thereof (gbe). Green coffee means all coffee in the naked bean form before roasting.

The International Coffee Organization (ICO) (01.05) has agreed on the following conversion factors to convert different types of coffee to gbe:

- Dried cherry to green bean: multiply the net weight of the cherry by 0.5;
- Parchment to green bean: multiply the net weight of the parchment by 0.8;
- Roasted coffee to green bean: multiply the net weight of the roasted coffee by 1.19;
- Soluble coffee to green bean: multiply the net weight of soluble coffee by 2.6;
- Liquid coffee to green bean: multiply the net weight of dried coffee solids contained in the liquid coffee by 2.6.

These conversion factors apply equally to decaffeinated coffee.

Alternatively, for statistical purposes: 60 kg green coffee represents:

- 120 kg dried cherry
- 75 kg parchment
- 50.4 kg roasted coffee

[5]green bean equivalent

Appendix 2. Variable Definitions

The processors (dis) selling price is quoted weekly by exporters for various grades of parchment coffee paid to processors. In this analysis, the data used are an arithmetic average of the quotations offered by the exporters across different grades and destinations and are not weighted by the volume of trade. The dis prices are converted to green bean equivalent and adjusted to fob price definitions for each of the export grades.

The factory door (fdr) buying price for parchment coffee is converted to green bean equivalent and adjusted to fob price definitions for each of the export grades. The factory-door price is an arithmetic average of all prices offered to growers for parchment at the factory door.

The dis price is converted to a parchment price by multiplying the figure with the average recovery rate, thereby accounting for weight losses between green bean and parchment. As noted in appendix 1, the standard conversion ratio of 1kg parchment = 0.8kg green bean is widely used in the PNG coffee industry. This standard conversion ratio is consistent with the ICO standard conversion ratio and is applied in many coffee producing regions. The complete calculations and the standard conversion ratios used in this study are given in the Appendix.

The exporter margin (EM) is the difference between the export price (fob) and the processor price (dis).

The processor margin (PM) is the difference between the processor price (dis) and the farm price or factory door (fdr) price.

The total margin (TM) measures the overall margin in the PNG coffee industry between export and farm. It is taken as a combination of the processor and exporters margins calculated as the differences between the export price (fob) and the farm price (fdr), using the same adjustments as for the fdr price.

EMC is an index of monthly marketing costs for exporters. The weights assigned to the components of EMC are based on the break-up provided by McGowans International (1988; cited from Tautea, 1992), as provided by the formula:

EMC = 0.220*(Transportation and Handling) + 0.270*(Customs and Wharfage) + 0.260*(Wages) + 0.250*(Other costs)

where transportation and handling costs are estimated from the transport and communications component of the CPI, customs and wharfage charges are estimated from the Lae CPI and the component of others is estimated from the fuel, rents and council charges component of the CPI.

PMC is an index of processing marketing costs based on cost data provided by Hassal and Associates (1982; cited from Tautea, 1992), as provided by the formula:

PMC = 0.2054*(Fuel) + 0.0982*(Labour) + 0.2500*(Sacks) + 0.4464*(Other costs)

where fuel data were estimated from the fuel, rent and council charges component of the CPI, wages were estimated from the index of wages provided in the Central Bank of PNG Quarterly Economics Statistical Bulletin, cost of sacks from the price index of jute and twine prices as provided in the UN Monthly Statistical Bulletin. The other component was estimated from the transportation and communication costs component of the CPI index.

Total market cost index (TMC) is the summation of EMC and PMC. The various marketing cost indexes calibrate the specified equations along the price axis.

The total quantity exported each month of all grades to all destinations is represented by the variable Q. This variable calibrates the specified equations along the quantity axis.

LEM= Lagged dependent variable of export margin, processor margin (LPM) and total margin (LTM), respectively, used in each of the equations in the various margin models.

Appendix 3. Summary of Unit Root Tests

1 Test Statistics

	EXPMARGIN	PROMARGIN	TOTMARGIN	WORLD	FOB
Wtd.Sym.	-5.85211	-3.33164	-5.34191	-4.13539	-3.98188
Dickey-F	-5.76395	-3.14221	-5.27251	3.88749	-3.79773
Phillips	-93.89233	-70.73353	-117.53568	-118.97516	-118.72438

	DIS	FDR	EMC	PMC	EXPVOL
Wtd.Sym.	-3.49927	-3.52088	-7.50067	-7.35557	-5.76078
Dickey-F	-3.26162	-3.28272	-7.37934	-7.30203	-5.54710
Phillips	-106.72613	-106.41279	-144.06033	-142.46937	-89.93235

2 P-values

	EXPMARGIN	PROMARGIN	TOTMARGIN	WORLD	FOB
Wtd.Sym.	0.000018437	0.033317	0.000084710	0.0031098	0.0049114
Dickey-F	6.78373D-06	0.096544	0.000063790	0.012622	0.016676
Phillips	2.88543D-09	7.42418D-07	9.58263D-12	6.76732D-12	7.19018D-12

	DIS	FDR	EMC	PMC	EXPVOL
Wtd.Sym.	0.020456	0.019201	1.33597D-07	2.06132D-07	0.000024224
Dickey-F	0.072807	0.069143	1.92947D-09	2.90123D-09	0.000018586
Phillips	1.30507D-10	1.40765D-10	1.58535D-14	2.32657D-14	7.48577D-09

3 Optimal number of lags

	EXPMARGIN	PROMARGIN	TOTMARGIN	WORLD	FOB
Wtd.Sym.	2.00000	3.00000	2.00000	3.00000	3.00000
Dickey-F	2.00000	3.00000	2.00000	3.00000	3.00000
Phillips	2.00000	3.00000	2.00000	3.00000	3.00000

	DIS	FDR	EMC	PMC	EXPVOL
Wtd.Sym.	3.00000	3.00000	2.00000	2.00000	2.00000
Dickey-F	3.00000	3.00000	2.00000	2.00000	3.00000
Phillips	3.00000	3.00000	2.00000	2.00000	3.00000