Estimation Procedure and Estimated Results of the KIPPRA–Treasury Macro Model

Alemayehu Geda
Stephen N. Karingi
Njuguna S. Ndung'u
Marein van Schaaijk
Maureen Were
Willis Wasala
John Obere

Macroeconomics Division
Kenya Institute for Public Policy Research and Analysis (KIPPRA)

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Bishops Garden Towers, Bishops Road
PO Box 56445, Nairobi, Kenya
tel: +254 2 719933/4
fax: +254 2 719951
email: admin@kippra.or.ke
website: http://www.kippra.org

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Contents

Acronyms

CES	constant elasticity of substitution
CPI	consumer price index
CUSUM	cumulative sum
ECM	error correction model
IFS	International Financial Statistics
ISS	Institute of Social Studies
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KTMM	KIPPRA–Treasury Macro Model
LDCs	least developed countries
MELT3	medium- to long-term model, version 3
MEPM	macro economic policy model for Kenya
MMC	Micromacro Consultants
OLS	ordinary least squares
SITC	Standard International Trade Classification

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1 Introduction

This document further[1] specifies and estimates the theoretical equations behind the KIPPRA–Treasury Macro Model (KTMM). Each of these equations is described in detail, and the estimation is organized around the following procedure. First, the theoretical underpinning of the estimated behavioural equation is explained. Following this brief exposition, econometrically estimable equations for the behavioural equations are specified. This is followed by a brief review of existing estimated results about the behavioural model in question. The review heavily draws on previous macro models of Kenya, such as the Chakrabarti—or the macro economic policy model for Kenya, version II (MEPM)—and the medium- to long-term model, version 3 (MELT3). This is followed by the actual estimation of the KTMM equations. An examination of the variables is made before the actual estimation of each equation. This is believed to inform the quality and properties of the time series data used for estimation. Finally, the results of the estimation and the plausibility of the estimated coefficients and their forecasting power, as well as their implication for the theory of KTMM, are discussed.

The general approach followed is to estimate each equation in two versions. The first version is a growth-based estimation. This is particularly important in showing the short-run variation of economic aggregates. Knowledge about short-run elasticities will help us to see how they adjust to their long-run values in a dynamic model. Since growth rates are generally a stationary series, estimation is done using ordinary least squares (OLS).

The second version of the equation is a level-based estimation. The elasticities derived using the level-based equations are important for future forecasts. The behavioural model in question is estimated by OLS. Since level-based estimations are prone to the spurious

[1] A separate theory paper contains details of the theoretical foundations behind the estimated equations in KTMM (see Huizinga et al. 2001).

regression problem, each of the variables is examined for its time series property using unit root analysis. As is usually the case with macroeconomic variables, all the variables (in levels) are found to be integrated of order one. This has prompted us to examine the cointegration property of the variables. Such a search is justified, as it is consistent with the theory used to motivate the equations. We again noted that all our behavioural equations had cointegrating vectors.. Provided that our data points and simulation properties permit, in this version we have estimated the long-run (equilibrium) relationships by realistically assuming that the theoretically specified equation forms one of the cointegrating vectors. We have left dynamic estimation of the models for future work.

In all the estimates reported in this document, our long-run estimation confirmed our theoretical specification of the steady-state relationships. Thus, we would like to emphasize that estimation using growth-rate and level-based versions should not be seen as separate processes. The underlining logic used is that growth-rate estimation shows us how the variables evolve towards their long-run values (i.e. short-run properties), while level-based estimation shows these long-run relationships. We have chosen this approach because it enormously simplifies (the technical) running of the macro model and allows separate studying of its property in the short and long run. At a later stage these two could easily be combined to come up with a dynamic specification that has an in-built adjustment mechanism. Moreover, when possible, the Kenya Institute for Public Policy Research and Analysis (KIPPRA) plans to pull each block of the macro model and carry out an in-depth dynamic analysis of each market using high-frequency data. The method for carrying out such analysis is documented in Alemayehu and Ndung'u (2001), and a recent output using this approach for the exchange rate block of KTMM is reported in Were et al. (2001). Readers also may benefit more from this report if they first go through the theoretical base of KTMM, which is reported in Huizinga et al. (2001).

The two versions of each behavioural equation are estimated for prices (section 2), wage rate determination (section 3), wage employment (section 4), private investment (section 5), imports (section 6), employment in the informal sector (section 7), private consumption (section 8), export supply (section 9), money demand and interest rate (section 10) and exchange rate determination (section 11).

2 Prices: Consumer, Investment and Export Prices

2.1 Consumer prices

Three price equations are estimated in the theoretical model (see Huizinga et al. 2001): consumer price, export price and price of investment. The theoretical underpinnings of these prices are similar, and are briefly outlined below.

2.1.1 The theoretical model and its empirical variant

In the theoretical model, the price equation is specified at a general level and for a single good. The specification begins by assuming a profit-maximizing agent who also pays profit tax. Working through this framework as shown in the theory paper will result in the definition of prices using marginal cost and price elasticity of demand. This is further manipulated to get a definition of prices as a function of average cost and capacity utilization. Average cost is in turn specified as a function of wage cost (net of productivity), import price and user cost of capital. Two final modifications are made to this equation. First, the impact of the competitors' price is taken into account. This has resulted in an equation, which would have been readily estimated had it not been for the lack of information on user cost of capital. Second, to circumvent the problem of measuring user cost of capital, this (user cost of capital) argument is substituted out assuming a constant rate of depreciation. This has resulted in the equation that is reproduced here in its compact form (see Huizinga et al. 2001).

$$\tilde{p}_j^{ms} = (1-\gamma_j)\left[\alpha_j \frac{dr}{r+\delta+\bar{r}} + \alpha_{wj}(\hat{w}-\hat{h}) + \alpha_{mj}\hat{p}_m + \beta 1_j \Delta q + \beta 2_j (q-1) + \frac{\Delta t_{:j} - \Delta s_{:j}}{1+t_{:j}-s_{:j}}\right] + \gamma_j \hat{p}_j^{comp}$$

Where P^{ms} = general price, r = real interest rate, δ = depreciation, w = wage rate, h = labour productivity indicator, q = capacity utilization, t = indirect taxes, s = subsidy, $\bar{r}$ = risk premium, P^{comp} = price of competitors, m,s (in superscript) indicates short-run market prices, and γ is the elasticity of final demand prices to competitor prices (see Huizinga et al. 2001 for details).

For consumer prices, the estimable counterpart of the above equation is

$$\dot{P}_t = \beta_0 + \beta_1 \dot{W}_t + \beta_2 \dot{P}_{mt} + \beta_3 \dot{r}_t + \beta_4 q_t + \beta_5 \dot{P}_t^{comp} + \varepsilon_t \qquad (1)$$

Where *the dot* over the variables shows they are in percentage change.

In the above equation the consumer price (P) is specified as a function of labour cost per unit of output (*w*), import prices (P_m) and real interest rate (*r*), which is incorporated in the process of substituting out user cost of capital. The latter is usually modelled using a time trend to show the effect of its movement over time; q and P^{comp} are indicators of capacity utilization and competitors' price, respectively.

2.1.2 Previous studies and their specification

In most industrialized countries standard macro models specify prices as a mark-up on costs, with a percentage increase in labour and import costs (capital costs are usually disregarded), leading to a percentage increase in prices. This, according to Whitley (1994: 121), is the case of the entire UK's non-monetarist model.

In developing countries, estimation of prices usually comes in the context of modelling inflation. There are two contending schools in this respect: the monetarist approach, where essentially prices are modelled as a function of monetary and fiscal variables, and the structuralist approach, where distribution of income and supply of food are central in the specification.[2] Agénor and Montiel (1996) propose a model that combines the two by introducing a subsidy to the food sector and a government budget constraint.[3]

There are also important research outputs for Kenya (for instance, see Killick and Mwega 1990; Ryan and Milne 1994; Durevall and Ndung'u 1999; and Ndung'u and Ngugi 1999). The early work of Killick and Mwega (1990) discussed inflation in the context of investigating monetary policy in Kenya. Using data from 1971 to 1988 they estimated a model that attempted to explain changes in consumer price with growth in real income, changes in money supply (M2), changes in import price, and previous years' inflation. The result showed that a percentage point increase in M2 was associated with a 0.25% increase in the price level, and that a 1% increase in import prices would raise the domestic price level by about 0.21%. Expectations, denoted by lagged inflation, were found to be insignificant. The strongest effect came from real GDP growth rate, which had an elasticity coefficient of –0.574 (using the whole sample period). Killick and Mwega argued that GDP growth had a negative effect on price, because it raised demand for money. Kiptui (1989), using a somewhat different model, found a strong effect of import price and money but not of income. Nganda (1985) found money and income to have a strong (negative) effect. Nganda (1985) did not use import price in the price equation.

2 See for instance Agénor and Montiel (1996) for algebraic detail.

3 The theoretical equation of the KTMM model may be revised along this line. This could be relevant, given the empirical finding that the price of maize is central to the evolution of prices in Kenya (see Durevall and Ndung'u 1999). The latter can also be incorporated in the existing specification by further specifying the unit labour cost as a function of food (maize) supply.

Ryan and Milne (1994) modelled inflation for lower, upper and middle-level income groups. They also attempted to model both monetary and institutional variables that could determine inflation in Kenya. The analysis began by specifying a quantity, theory-based money-demand equation. At the empirical stage, this model was modified to include supply-side effects (with cement production as its proxy), demand-side effects (captured by tea and coffee production) and institutional variables such as the gas oil price, a dummy for price control on maize, and exchange rate. They found that the model generally fitted the data well.

For Durevall and Ndung'u (1999), long-run inflation in Kenya depended on exchange rate, terms of trade and foreign prices, and short-run inflation on money supply and interest rate. They also noted that food supply affects inflation dynamics in the short run, and that inflation inertia was high until 1993, but dropped sharply thereafter. This was accompanied by the interest rate (Treasury bill) hike after 1992. Durevall and Ndung'u (1999) stressed the theoretical nature of previous studies and underscored the importance of taking price formation through money demand and supply and purchasing power parity, upon which their work was based.

The latter avenue is followed in Ndung'u and Ngugi (1999). They developed inflation dynamics by modelling determinants of inflation in three stages. In the first stage they modelled domestic inflation in the context of a money market with an error correction mechanism (ECM) set-up. In the second stage they modelled the foreign component of inflation using nominal exchange rate and world price in an ECM set-up. Finally, in the third stage the two models were brought together to generate a combined dynamic model of inflation for Kenya.

Prices feature prominently in Kenyan applied macro models. This can be seen in both MEPM (GoK 1994) and MELT3 (Keyfitz 1994) versions.

In MELT3, price is specified to depend on unit labour cost, with a unit elastic price response imposed.[4] Supply shocks are captured in price equations by including the ratio of the particular sector's output (such as non-coffee and non-tea agriculture) to GDP. It is also assumed that prices will respond to the discrepancy between their expected and actual level. Based on such specification, various sectoral deflators are generated. Of these, consumer price index (CPI) is of great interest to us.

The authors of MELT3 noted that CPI data were not good. At the time of their estimation, work on a revised series was available only up to 1986, and they constructed a series up to 1989 using statistical 'bridging techniques'. Despite the elaborated theoretical discussion about determinants of prices, the final CPI equation (rate of change in the Nairobi CPI) is estimated as a function of the rate of change in the deflator of consumption (PCONS) and share of imports in GDP. PCONS is a measure of the cost of consumption constructed as a weighted average of domestic GDP at factor cost deflator, and goods (not services) import deflator grossed by duties and indirect taxes. The final estimated equation is given as

$$\Delta CPI = 0.071 + 1.135\Delta PCONS - 0.594(M/GDPMP)$$

(0.53) (9.8) (-2.7)

$RBAR^2 = 0.95$; D-W = 2.43; n = 16

Figures in parentheses are t-values.

MEPM assumes that price, particularly CPI, is affected by both cost-push and demand-pull factors. The ratio of stock of money to GDP and the velocity of money (interest rate as its proxy) are used on the demand side. Nominal exchange rate, index of unit wage cost, and capacity utilization indicator are used as important factors on the

[4] It was noted that in unrestricted regression, elasticities are found to be greater than 1.

cost-push side. Using such arguments, the estimated CPI equation is given as

$$\text{LnCPI} = \underset{(3.4)}{1.3090} + \underset{(8.34)}{0.2804}\ln(\text{M2DEC}_{-1}/\text{RGPFC}) + \underset{(14.8)}{0.2850}\ln\text{XCHU\$} +$$

$$\underset{(26.94)}{1.0472}\ln\text{UWCDX}_{-1} - \underset{(-11.93)}{1.0331}\ln\text{UTLR} - \underset{(-5.88)}{0.0764}\text{D7677}$$

$R^2 = 9998$; $RBAR^2 = 0.9997$; D-W = 2.11; n = 20

Figures in parentheses are t-values.

Where M2DEC = end of year M2, RGPC = real GDP at factor cost, XCHU$ = nominal exchange rate (of shilling to dollar), UWCDX = unit cost of labour, UTLR = capacity utilization rate, and D = dummy for 1976/77.

These are the actual equations used in the two applied models for Kenya. These estimations provide us with the starting point for estimating price equations, and an idea of what the likely coefficients might be. Moreover, basically they include almost all the determinants of prices envisaged in the new KTMM.

However, there is one major difference between the two models and KTMM in the specification of the impact of money supply on prices. Both MELT3 and MEPM have explicitly incorporated money supply in their estimated price equations. This approach, though it appears intuitive, does not help us to see the channel through which the money supply affects the price level. In contrast, KTMM explicitly outlines monetary policy propagation mechanisms. This implies that the price equations implicitly embody money supply (see Huizinga et al. 2001). In other words, impact of money supply on prices works its way through interest rate. Interest rate, in turn, determines exchange rate. The latter affects the level of aggregated demand, which, together with aggregate supply for a given level of capacity utilization, determines the level of price. This price will, in turn, have a feedback effect on the money market (through demand for money). This, in a nutshell, implies that KTMM runs away from the simple quantity theory equation.

The introduction in KTMM of the framework to incorporate capacity utilization in price formation is also quite innovative. The existing models must have tacitly assumed that there was full capacity utilization. Departing from such an assumption allows the possibility of showing fix-price (adjustment through output clearing) and flexi-price (adjustment through price) adjustment mechanisms jointly in the model.

Another weakness of the existing Kenyan applied models discussed above is that they pick explanatory variables on an ad hoc basis. Thus, KTMM has an edge over them in that its estimable equations are derived from a well-specified, theoretical model (that is, from first principle). The next issue is to examine whether this specification concurs with the data. This is the subject of the next section.

2.1.3 Estimation for KTMM: consumer prices

Data used

- *Real interest rate (INTREAL)* is generated by subtracting inflation rate from the short-term interest rate.

- *Capacity utilization* is derived as a ratio of actual GDP to potential GDP (see annex 1).

- *Competitor's price.* For a consumer good, the ideal competitor is a foreign import. However, import price is already included in the function as an explanatory variable.

Growth-based model: consumer prices (short-run model)

The correlation matrix (table 2) shows that the explanatory variables are not highly correlated; therefore, a high degree of multicollinearity is not expected.

Table 1. Definition of variables

Variable	Symbol for levels	Symbol for growth rate (% change)
Consumer price	CHPI	CHPP
Labour cost per unit output	LUQI	LUQP
Import price	MPI	MPP
Real interest rate	INTREAL	INTREAL
Capacity utilization	QRATE1	QRATE1

Table 2. Correlation matrix

	CHPP	LUQP	MPP	TBRY	QRATE1
CHPP	1				
LUQP	0.15	1			
MPP	0.53	–0.05	1		
TBRY	0.14	0.37	–0.027	1	
QRATE1	–0.396	–0.35	–0.026	–0.3	1

Estimation results of the growth-based equation are given below:

$$CHPP = \underset{(0.44)}{0.08735442295LUQP} + \underset{(2.25)^{**}}{0.3139882947MPP} - \underset{(-0.96)}{0.2439314569TBRY}$$

$$- \underset{(-0.58)}{29.53518703QRATE1} + \underset{(1.4)}{11.09307764D7593} + \underset{(0.8)}{5.88651257D93}$$

$$+ \underset{(0.7)}{38.53943182}$$

$R^2 = 0.50$; D-W = 2.47; J-B = 0.91 (0.63); BG = 2.8(0.10); $RBAR^2 = 0.32$; F =2.86*; RESET = 0.00 (0.99); LM = 3.2 (0.099); n = 24

Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

Note:

In the diagnostic test, values in parentheses are P-values for J-B, BG, RESET and LM; where J-B = Jarque Bera normality test, BG = Breusch-Godfrey serial correlation test; RESET = Ramsey's specification test, and ARCH LM = heteroschedasticity

Estimation of this equation gives theoretically plausible results that are sensitive to the shocks of 1975 and 1993. Various dummies representing this period are found to be insignificant. Using the CUSUM test, the growth-based equation is found to be fairly stable. However, only import price is significant. This shows that growth-based consumer price function cannot be successfully estimated from these data. The most probable causes are either that the data points are too few or that there is a large level of aggregation. The latter might be resolved if high-frequency data are used. Alternatively, it might show that imports are important factors in the short run.

Constrained estimation: growth-based consumer price

Another estimation of the growth-based equation is made imposing the restriction that the sum of the cost components needs to add to one. In the estimation, the coefficients of LUQP, MPP and TBRY are constrained to add to unity. This result is reported below:

$$CHPP = \underset{(1.44)}{0.297205LUQP} + \underset{(3.6)^*}{0.495041MPP} + 0.207754TBRY - \underset{(-1.01)}{57.5365QRATE1}$$

$$+ \underset{(0.17)}{1.23644D7593} - \underset{(-0.54)}{3.603354D93} + \underset{(0.99)}{57.90227}$$

$R^2 = 0.29$; D-W = 2.47; $RBAR^2 = 0.10$; F = 1.5*; n = 24

Figures in parentheses are t-values, and * shows significance 1%.

Level-based estimation: consumer prices (long-run model)

The correlation matrix (table 3) shows that the explanatory variables are highly correlated. This will definitely cause multicollinearity. However, it will not create a problem if a dynamic model is used. Though this will cause problems, especially unreliability of statistical tests, OLS estimates remain the most efficient.

Time series properties can be read also from unit root and cointegration tests in tables 4 and 5, respectively. The variables are found to be non-stationary (except QRATE1, which, understandably, is stationary), but have a cointegrating vector (identified to be two at most) and, hence, a long-run relationship. This possible long-run relationship is estimated below.

Table 3. Correlation matrix of the level-based regression

LCHPI	LLUQI	LMPI	LTBRY	LCHPP
1				
0.99	1			
0.98	0.97	1		
0.85	0.83	0.89	1	
−0.03	−0.03	−0.05	0.08	1

Table 4. Summary of unit root tests*

Test	LCHPI	LLUQI	LMPI	LTBRY	CHPP	QRATE1
ADF	0.0003	0.65	−2.17	−1.16	−2.51	−3.38
PP	−0.27	1.09	−2.42	−1.43	−5.08	−2.7

*1 and 5% levels of significance for both tests are −3.73 and −2.99, respectively.

Table 5. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
r = 0	0.92	115.95	68.52	76.07
r ≤ 1	0.79	59.49	47.21	54.46
r ≤ 2	0.53	24.94	29.68	35.65
r ≤ 3	0.3	8.31	15.41	20.04
r ≤ 4	0.02	0.38	3.76	6.65

Further examination of the data reveals numerous outliers. These are handled by introducing appropriate dummy variables. The estimation is very sensitive to the period after 1993. Attempting to use dummy variables for 1993 to 1997 does not yield good results. However, when this period is excluded altogether the results improve, although it renders very short data points. Thus, for years 1976, 1979 and 1994 dummies are used instead. The final results are reported below. Note also that real interest rate is disaggregated (into nominal interest rate and inflation rate) to circumvent the problem of losing data points when logarithms are taken, because for many years real interest rate was negative.

$$LCHPI = 0.04226506925 + 0.6583936549LLUQI + 0.3481647302LMPI$$
(0.8) (21)* (9.5)*

$$- 0.04285663044LTBRY + 0.002696936723LCHPP$$
(-2.2)** (0.38)

$$+ 0.06364511367D7679 - 0.1515819371D94$$
(2.81)* (-4)* (0.8)

R^2 = 0 .999; D-W = 1.73; J-B = 0.19 (0.90); BG = 0.04 (0.0.8); n = 24
RBAR^2 = 0.998; F = 2864*; RESET = 0.0.3 (0.58); LM = 0.8 (0.37),
Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

The estimation is good in terms of diagnostic tests. However, capacity utilization is statistically insignificant. Its exclusion significantly improves the model. This might be logical, because we expect full capacity utilization in the long run. More importantly, this long-run relationship is in line with the theory specified for KTMM.

Constrained estimation: level-based consumer price

Another estimation of the level-based equation is made imposing the restriction that the sum of the cost components needs to add to one. In the estimation, the coefficients of LUQP, MPP and TBRY are constrained to add to unity. This result is reported below:

$$LCHPI = -0.054647 + 0.680025LLUQI + 0.332074LMPI - 0.025587LTBRY +$$
(-1.13) (18.6)* (7.65)* (-1.12)

$$0.013488LCHPP + 0.074423D7679 - 0.173289D94$$
(2.75)* (-4.6)*

R^2 = 0.999; D-W = 1.38; RBAR^2 = 0.998; F = 2342; n = 24
Figures in parentheses are t-values, and * shows significance at 1%.

2.2 Export prices

2.2.1 The theoretical model and its empirical variant: export price

The theoretical underpinning of the export price equation is fundamentally the same as the one for the consumer price equation specified in the previous section. The estimable variant is given as

$$\dot{P}x_t = \beta_0 + \beta_1 \dot{W}_t + \beta_2 \dot{P}_{mt} + \beta_3 \dot{r}_t + \beta_4 q_t + \beta_5 \dot{P}_t^{comp} + \varepsilon_t \quad (2)$$

Where Px_t = is price of exports, and all other variables are as defined before.

2.2.2 Previous studies and their specification: export price

The small-country assumption that is usually employed in analysing developing countries such as Kenya enormously simplifies the estimation of export prices. This is indeed the case in the two previous applied Kenyan macro models.

Export prices in MELT3 are defined using identities to track world prices. This is done for tea, coffee, oil, services and other exports. All the prices are scaled to equal 100 in 1982 and, using the small-country assumption, are defined as follows:

PXCoffee = 7.28985*FxKsUSD*USPCoffee*ZPXCoffee

PXTea = 10.451391* FxKsUSD*USPTea*ZPXTea

PXOil = 0.273640 FxKsUSD*USPOil*ZPXOil

PXOth = FxKsUSD*USPGNP*ZPXOthers

PXS = FxKsUSD*USPGNP*ZPXS

Where PX = export price, FxKsUSD = exchange rate of US dollar to the Kenya shilling, S = services; USP = price in US dollars.

It is not clear how the different coefficients in the above equations are derived in MELT3.

Total export price deflator in MEPM is generated using historical data for coffee and tea. This is justified, since these two items constituted nearly 75% of the export earnings of the SITC (Standardized International Trade Classification) categories 0 and 1 (this price deflator is defined as DFX01 below). Coffee and tea prices are in turn projected based on exogenous projections of their world price in US dollars, and a projection of the change in the Kenyan exchange rate. For the SITC categories 2 to 4 (named DFX24 below) and 5 to 9 (named DFX59 below), import price also is allowed to determine their price. These three estimated (dummies included) equations are given as

$$\ln DFX01 = \underset{(54.91)}{1.6701} + \underset{(22.22)}{0.4885}\ln PXCOF + \underset{(22.21)}{0.4617}\ln PXTEA + \underset{(3.15)}{0.0830}D76 - \underset{(-5.02)}{0.694}D82T85 + \underset{(1.87)}{0.0477}F91$$

$R^2 = 0.999$; $RBAR^2 = 0.9986$; D-W = 2.05; n = 21

Figures in parentheses are t-values.

$$\ln DFX24 = \underset{(-1.62)}{-0.352} + \underset{(23.3)}{1.0466}\ln PM24 - \underset{(-3.22)}{0.2649}D77Y79 - \underset{(-4.3)}{0.3571}D83T85$$

$R^2 = 0.9707$; $RBAR^2 = 0.9658$; D-W = 1.78; n = 21

Figures in parentheses are t-values

$$\ln DFX59 = \underset{(10.04)}{0.7886} + \underset{(49.24)}{0.8193}\ln PM59 + \underset{(4.62)}{0.1762}D76T79 - \underset{(-6.11)}{0.2219}D86T89$$

$R^2 = 0.9936$; $RBAR^2 = 0.9926$; D-W = 2.09; n = 21

Figures in parentheses are t-values.

2.2.3 Estimation for KTMM: export price

Data used

A summary of the variables used in the estimation of the export price equation (specified below) is given in table 6.

Table 6. Definition of variables

Variable name	Symbol (levels)	Symbol (growth rates—% change)
Export Price (dependent variable)	BPI	BPP
Import price	MPI	MPP
Real interest rate	INTREAL (TBRY – CHPP)	INTREAL (TBRY – CHPP)
Capacity utilization	QRATE1 (derived – see below)	QRATE1
Competitor price	PCOMPX (derived-see below)	PCOMPXP (calculated as [(PCOMPX-PCOMPX(-1)) /PCOMPX(-1)]*100
Labour cost per unit of output	LUQI	LUQP

Note:

Capacity utilization (QRATE1) = actual real GDP (GDREAL)/potential real GDP (GDPCAP) (see annex 1)

Competitor price (PCOMPX) is computed as a weighted average of prices of tea and coffee offered by Kenya's competitors, i.e. PCOMPX = 0.58Ptea + 0.42Pcoffee, where 0.58 and 0.42 are computed based on the average value of Kenya's tea and coffee exports for the period 1993–1997.

Price of tea (Ptea) = world price of tea (average auction, London) obtained from International Finance Statistics (IFS).

Price of coffee (Pcoffee) = competitor price of coffee—Uganda (New York), obtained from IFS.

Growth-based estimation (short-run model)

As can be seen from the correlation matrix in table 7, we do not expect multicollinearity to be a serious problem. However, two of the explanatory variables (labour cost per unit of output and competitors' price) are relatively highly correlated with the dependent variable (export price). This is an indication of the expected significance of the two variables in the export equation. In fact, as we noted above, if we have to use an ECM, multicollinearity will not be a problem at all.

Table 7. Correlation matrix of growth-based variables

	BPP	LUQP	MPP	INTREAL	QRATE1	PCOMPXP
BPP	1					
LUQP	0.61	1				
MPP	0.27	−0.05	1			
INTREAL	0.14	0.05	−0.31	1		
QRATE1	−0.32	−0.35	−0.026	0.06	1	
PCOMPXP	0.58	0.47	−0.02	−0.32	−0.39	1

The estimated export price (growth-based) equation using all the explanatory variables described above is given in annex 2.1. Analysis of the residuals of this model reveals a shock/outlier in the series, which necessitates inclusion of a dummy for 1995. The dummy is negatively signed and very significant (this estimation is also shown in annex 2.1). All other variables are statistically significant as before, except capacity utilization (both current and lagged values), which becomes statistically insignificant with the addition of the dummy. However, the specification and diagnostic tests, including the normality test, are fairly good. This equation is then re-estimated excluding capacity utilization. This yields the parsimonious equation given below:

$$BPP = \underset{(-4.14)^*}{-28.15568953D95} + \underset{(2.93)^*}{0.3536304491INTREAL} + \underset{(3.97)^*}{0.7148204819LUQP} +$$

$$\underset{(4.11)^*}{0.290243877PCOMPXP} + \underset{(4.16)^*}{0.4927276017MPP} - \underset{(-0.81)}{2.40734157}$$

$R^2 = 0.86$; D-W = 1.73; F = 22.06*; J-B = 1.37 (0.51); BG = 0.33 (0.56); n = 24

$RBAR^2 = 0.82$; ARCH (LM) = 0.16 (0.74); RESET = 0.014 (0.90)

Figures in parentheses are t-values, and * shows significance at 1%.

This model may be considered the preferred one, since it gives statistically significant, theoretically plausible results and better diagnostic tests. In summary, the growth of export price is highly influenced by the growth of import price, foreign competitors' price,[5] labour cost per unit of capital and real interest rates. In addition, what happened in 1995 had a significant negative effect on the growth of export price. That year followed the appreciation of the shilling in 1994. Capacity utilization appears to be insignificant and also its effect is unpredictable. Parameter stability is established using the CUSUM test.

Constrained estimation: growth-based export price

Another estimation of the growth-based equation is made imposing the restriction that the sum of the cost components needs to add to one. In the estimation, the coefficients of LUQP, MPP and INTREAL are constrained to add to unity. The results are reported below:

BPP = 0.218807INTREAL + 0.464808 LUQP + 0.316385MPP +
(1.85)*** (2.9)* (3.9)*

0.305931PCOMPXP – 32952863D95 + 3.285018
(3.9) (-3.9)* (1.761)***

R^2 = 0.82; D-W = 1.36; F = 21.13*; RBAR^2 = 0.78; n = 24

Figures in parentheses are t-values, and * and *** show significance at 1 and 10%, respectively.

Level-based estimation

All the variables are in logarithm form, except INTREAL (because of negative values).

The correlation matrix of variables in levels (table 8) shows that there is a nearly perfect correlation between LLUQI and LMPI. There is also a relatively high correlation between LMPI and INTREAL. To reduce the degree of multicollinearity, the estimation procedure

[5] Note that nominal exchange rate will have a similar effect, since it converts this foreign price into domestic price equivalent.

includes an equation without one of the correlated variables (see below).

Table 8. Correlation matrix of the variables in levels

	LBPI	LLUQI	LQRATE1	LMPI	LPCOMPX	INTREAL
LBPI	1					
LLUQI	0.99	1				
LQRATE1	–0.21	–0.25	1			
LMPI	0.98	0.97	–0.1	1		
LPCOMPX	–0.07	–0.13	0.12	–0.08	1	
INTREAL	0.61	0.54	0.07	0.6	– 0.04	1

The unit root tests in table 9 show that all the variables are non-stationary (in levels).

Table 9. Unit root test (on levels)

Test	LPCOMPX	LBPI	LMPI	LLUQI	INTREAL	LQRATE1
ADF	–2.696	–0.35	–1.11	1.02	–2.43	–1.49
PP	–2.75	–0.62	–2.43	1.1	–3.76	–1.73

*The 1, 5 and 10% levels of significance for both tests are –3.74, –2.99 and –2.64, respectively.

The cointegration test (table 10) indicates a possibility of two cointegrating vectors at 1% level of significance, and at most four at the 5% level.

Table 10. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
r = 0	0.976146	211.24	94.15	103.18
r ≤ 1	0.909045	129.05	68.52	76.07
r ≤ 2	0.852242	76.31	47.21	54.46
r ≤ 3	0.626632	34.24	29.68	35.65
r ≤ 4	0.285489	12.57	15.41	20.04
r ≤ 5	0.209565	5.17	3.76	6.65

Having recognized the possibility of a long-run relationship, the export equation is estimated using all the explanatory variables. The estimation results appear theoretically plausible, and all the variables, except LQRATE1, are statistically significant and have the expected signs. However, the probability value for the normality test is too low, and the conclusions made may not be valid. An attempt is made to improve the results by using dummies to model the shocks revealed by examining the data, particularly for 1978, 1992, 1994 and 1996. Re-estimation is then done using different period dummies. All versions of the dummies are found to be significant in most cases and to yield fairly similar results in terms of magnitude, signs and level of significance, as well as diagnostic tests. However, the equation that included D789294 (dummy for 1978, 1992 and 1994)—these were probably the second oil shock and the period of liberalization—was preferred because it yielded slightly better diagnostic and specification results. The estimation results are given below. The results confirm our theoretical expectation and, hence, depict the steady state situation. The estimation without a dummy is reported in annex 2.2:

LBPI = 0.1749937017D789294 + 0.005794835507INTREAL –
(5.66)* (5.84)*

0.373379128LQRATE1 + 0.1501853588LPCOMPX+ 0.2458962342LMPI
(-1.28) (3.32)* (4.06)*

+ 0.7115479837LLUQI – 0.4950961217
(11.42)* (-2.13)**

R^2 =0.997; D-W = 1.92; F = 1114.97*; J-B = 0.78 (0.68); BG = 0.34 (0.84)
RBAR^2 = 0.996; ARCH LM = 0.18 (0.91); RESET = 0.75 (0.39); n = 24
Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

LLUQI and LMPI are highly correlated in the model reported above and in annex 2.2. Since all the variables are nonstationary in levels (but cointegrated with others in the model), multicollinearity may not be a serious problem in a dynamic model. Nonetheless, re-estimation was done excluding the correlated variables one at a time, starting with LMPI. Even with the inclusion of dummies where necessary, the estimation results without LMPI showed better diagnostic and specification test results. After attempting a number of regressions, a fairly better model emerged. The latter equation includes a dummy for 1996. This result is reported in annex 2.3.

In conclusion, the estimated results of the level-based equation are more or less similar to those of the growth-based equation in terms of coefficient signs and statistical significance. However, the magnitude of the coefficient for real interest rates (INTREAL) is much smaller in the level-based than the growth-based equation. Capacity utilization (QRATE1) is statistically insignificant in both cases. The estimated results further show that the dummy for 1978, 1992 and 1994 (D789294) has a positive effect, while that for 1995 and 1996 has a negative impact on export price. The period 1977/78 captures the coffee boom effect, while 1992, 1994–96 may be capturing the liberalization period.

Constrained estimation: level-based export price

Another estimation of this level-based equation is made imposing the restriction that the sum of the cost components needs to add to one. In the estimation, the coefficients of LUQP, MPP and INTREAL are constrained to add to unity. This result is reported below:

LBPI = 0.004614INTREAL + 0.246483LMPI + 0.748903LLUQI +

(4.8)* (3.6)* (-1.28)

0.160589LPCOMPX – 0.188279LQRATE1 + 0.165366*D789294 –

(1.28) (-0.60) (4.8)*

0.731085

(-3.1)*

R^2 = 0.996; D-W = 1.68; F = 1063.5*; $RBAR^2$ = 0.995; n = 24

Figures in parentheses are t-values, and * shows significance at 1%.

2.3 Investment price

2.3.1 The theoretical model and its empirical variant: investment price

The theoretical underpinning of the investment equation is the same as for the two price equations above. The estimable equation is given as

$$\dot{PI}_t = \beta_0 + \beta_1\dot{W}_t + \beta_2\dot{P}_{mt} + \beta_3\dot{r}_t + \beta_4 q_t + \beta_5\dot{P}_t^{comp} + \varepsilon_t \qquad (3)$$

Where PI_t = is price of investment and all the other variables are as defined before.

2.3.2 Previous studies and their specification: investment price

In MELT3, real investment spending is estimated for a list of production sectors: traditional (T), agriculture (A), manufacturing (M), services (S) and government (G). The associated deflators (investment prices) are estimated independently. Nominal investment is then computed using identities. The estimated investment deflators for each sector are provided below:

Log (T/PGDPFC) = -0.159 + 0.425Log{PMNoil*(1 + 0.01*RTDutyNoil)/PGDPFC}
(-11.7) (8.82)

RBAR² = 0 84; D-W = 1.14; n = 16

Figures in parentheses are t-values, and * shows significance at 1%.

Log (A/PGDPFC) = -0.113 + 0.323Log{PMNoil*(1 + 0.01*RTDutyNoil)/PGDPFC}
(-5.81) (2.8)

+ 0.38Log{PMNoil*(1 + 0.01*RTDutyNoil)/PGDPFC}$_{t-1}$
(3.8)

RBAR² = 0.96; D-W = 2.16; n = 16

Figures in parentheses are t-values, and * shows significance at 1%.

$$\text{Log}(M/PGDPFC) = \underset{(-6.49)}{-0.16} + \underset{(3.84)}{0.557}\text{Log}\{PMNoil^{*}(1 + 0.01^{*}RTDutyNoil)/PGDPFC\}$$

$$+ \underset{(3.25)}{0.412}\text{Log}\{PMNoil^{*}(1 + 0.01^{*}RTDutyNoil)/PGDPFC\}_{t-1}$$

$RBAR^2 = 0.96$; D-W = 2.47; n = 16

Figures in parentheses are t-values, and * shows significance at 1%.

$$\text{Log}(S/PGDPFC) = \underset{(-5.76)}{-0.09} + \underset{(3.50)}{0.336}\text{Log}\{PMNoil^{*}(1 + 0.01^{*}RTDutyNoil)/PGDPFC\}$$

$$+ \underset{(3.90)}{0.327}\text{Log}\{PMNoil^{*}(1 + 0.01^{*}RTDutyNoil)/PGDPFC\}_{t-1}$$

$RBAR^2 = 0.97$; D-W = 1.66; n = 16

Figures in parentheses are t-values, and * shows significance at 1%.

$$\text{Log}(G/PGDPFC) = \underset{(-3.57)}{-0.07} + \underset{(2.0)}{0.24}\text{Log}\{PMNoil^{*}(1 + 0.01^{*}RTDutyNoil)/PGDPFC\}$$

$$+ \underset{(1.64)}{0.172}\text{Log}\{PMNoil^{*}(1 + 0.01^{*}RTDutyNoil)/PGDPFC\}_{t-1}$$

$RBAR^2 = 0.87$; D-W = 1.43; n = 16

Figures in parentheses are t-values, and * shows significance at 1%.

The deflators above are used to generate the nominal level of investment in each sector. This, combined with aggregate real investment, is used to generate total investment deflator.

Like with MELT3, MEPM's estimation of investment price (deflator) is motivated by the need to convert estimated real investment into its nominal counterpart. Two investment categories—fixed capital formation and change in inventory—are identified in the model. However, the investment price for inventories is derived from that for fixed capital formation. Fixed capital formation deflator (KFDF) is specified as a function of lagged GDP deflator (DFGDP) and price of imports (PM):

$$LnKFDF = -0.8271 lnDFGDPt\text{-}1 + 0.3212 lnPM$$

(-5.27) (5.71)

$R^2 = 0.9980$; $RBAR^2 = 0.9978$; D-W = 2.08; n = 20

Figures in parentheses are t-values.

Nominal value of change in stock (NΔSTK) is derived by simply relating it to real level of change in stock (RΔSTK) and the capital formation deflator estimated above. Dummies also are used to capture some changes. This equation is given below:

$$N\Delta STK = -78.8633 + 1.057\, R\Delta STK + 0.8824 KFDF + 91.68 D8889 - 202.19 D9293$$

(-2.9) (6.76) (5.42) (2.48) (-3.77)

$R^2 = 0.9288$; $RBAR^2 = 0.9068$; D-W = 2.19; n = 17

Figures in parentheses are t-values.

2.3.3 Estimation for KTMM: investment price

Data used

- *Capacity utilization (QRATE1).* This is derived as a ratio of actual output to potential (capacity) output (see annex 1).
- *Competitor prices (PCOMPI).* A weighted average of wholesale export prices from three principle trading partners of Kenya (USA, UK and Japan), extracted from an International Finance Statistics (IFS) database, is used as a proxy for competitor prices. A five-year (1994–1998) average export value (to Kenya) from each of the trade partners is used in computing the weights.
- *Real interest rate (INTREAL).* This is generated by subtracting inflation rate (CHPP) from T-bill rate (TBRY).

Table 11 shows the other variables used.

Table 11. Definition of variables

Variable	Symbol for level-based model	Symbol for growth-based model
Price of investment	IPI	IPP
Labour cost per unit output	LUQI	LUQP
Import price	MPI	MPP
Real interest rate	INTREAL derived	INTREAL derived
Capacity utilization	QRATE1 derived	QRATE1 derived
Competitor price	PCOMPI derived	DPCOMPI derived (PCOMPI – PCOMPI(-1))/PCOMPI(-1)

Growth-based estimation

Table 12. Correlation matrix for the growth-based model

	IPP	LUQP	MPP	INTREAL	QRATE1	DPCOMPQ
IPP	1					
LUQP	0.26	1				
MPP	0.51	-0.05	1			
INTREAL	0.033	0.049	-0.3	1		
QRATE1	-0.17	-0.35	-0.03	0.06	1	
DPCOMPQ	0.23	-0.2	0.39	-0.29	0.17	1

The correlation matrix shows that the explanatory variables are not highly correlated as to cause multicollinearity. Accordingly, the growth-based estimation is reported below:

$$IPP = \underset{(1.7)^{***}}{0.283050027LUQP} + \underset{(2.4)^{**}}{0.3344855931MPP} + \underset{(1.19)}{0.1414545288INTREAL} +$$

$$\underset{(0.84)}{20.57929656DPCOMPI} + \underset{(1.25)}{4.072236045QRATE1} + \underset{(0.04)}{0.2967560439D75} +$$

$$\underset{(0.6)}{4.529336012D82}$$

$R^2 = 0.42$; D-W $=1.94$; J-B $= 0.69$ (0.70); BG $= 0.17$ (0.68); $n = 24$
RBAR$^2 = 0.16$; F $=1.64^{*}$; RESET $=1.6$ (0.21); ARCH LM $= 0.59$ (0.44)

Figures in parentheses are t-values, and *, ** and *** show significance at 1, 5 and 10%, respectively.

The estimated results are theoretically plausible; however competitors' price is shown to be insignificant. The RESET test statistic is rather low. This may imply that the growth-based model for investment price, which is believed to show the short-run dynamics, may need to be further specified, perhaps in a dynamic model.

Constrained estimation: growth-based investment price

Another estimation of this growth-based equation is made imposing the restriction that the sum of the cost components needs to add to one. In the estimation, the coefficients of LUQP, MPP and INTREAL are constrained to add to unity. This result is reported below:

IPP = 0.382133LUQP + 0.410323MPP + 0.207544INTREAL +
(3.0)* (3.8)* (0.84)

22.29443DPCOMPI + 1.632942QRATE1 + 0.129460D75 + 5.087445D82
(0.81) (0.02) (0.69)

$R^2 = 0.36$; D-W = 2; F = 2.1**; n = 24; $RBAR^2 = 0.19$

Figures in parentheses are t-values and * and ** show significance at 1 and 5%, respectively.

Level-based estimation

Table 13. Correlation matrix for level-based regression

	LIPI	LMPI	INTREAL	LPCOMPI	QRATE1
LIPI	1				
LMPI	0.99	1			
INTREAL	0.6	0.6	1		
LPCOMPI	0.95	0.95	0.58	1	
QRATE1	–0.13	–0.1	0.06	0.13	1

The correlation matrix (table 13) shows that all the variables, except capacity utilization, are highly correlated. This might lead to a multicollinearity problem. OLS estimates still remain the most efficient. Leaving out the most insignificant variable (PCOMPI) makes little difference to the value of coefficients of other variables and their statistical significance. Adding samples or disaggregating existing ones may help solve the multicollinearity problem in the short-run model.

Time series properties can be read also from the unit root and cointegration tests (tables 14 and 15), respectively) where the variables are found to be individually non-stationary but to have at most two cointegrating vectors and, hence, a long-run relationship. One of these possible long-run relationships is estimated below:

LIPI = 0.586750LLUQI + 0.4728377LMPI + 0.001844INTREAL +
(9.3)* (7.9)* (2)

0.0349819LPCOMPI + 1.020025LQRATE1 +
(0.19) (2.26)**

0.056131D75 – 0.109288D82 – 0.329184
(1.07) (-2.3)** (-0.7)

R^2 = 0.998; D-W = 1.9; J-B = 1.0 (0.59); BG = 0.03 (0.84); n = 24
$RBAR^2$ = 0.997; F = 1327.0*; RESET = 0.01 (0.91); LM = 2.3 (0.13)
Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

Table 14. Summary of unit root tests*

Test	LLUQI	LMPI	INTREAL	LPCOMPI	QRATE
ADF	0.65	–2.17	–2.53	–2.71	–3.38
PP	1.09	–2.42	–3.76	–4.27	–2.7

*1 and 5% levels of significance for both tests are –3.73 and –2.99, respectively.

Table 15. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
r = 0	0.921744	137.95	68.52	76.07
r ≤ 1	0.892533	79.35	47.21	54.46
r ≤ 2	0.619812	28.04	29.68	35.65
r ≤ 3	0.177108	5.8	15.41	20.04
r ≤ 4	0.055652	1.32	3.76	6.65

The estimation passes all diagnostic tests. All variables, except capacity utilization, are theoretically plausible, and all of them, except competitor prices, are statistically significant. However, excluding competitor prices from the model does not change the estimated result very much. This result basically shows the long-run relationship towards which the variables, as depicted in the growth-based equation, will eventually evolve.

Constrained estimation: level-based investment price

Another estimation of this level-based equation is made imposing the restriction that the sum of the cost components needs to add up to one. In the estimation, the coefficients of LUQP, MPP and INTREAL are constrained to add to unity. This result is reported below:

$$\underset{}{LIPI} = \underset{(10.3)^*}{0.554666LLUQI} + \underset{(8.24)^*}{0.443438LMPI} + \underset{(4.8)^*}{0.001896INTREAL} + 0.202763LPCOMPI$$

$$+ \underset{(2.5)^*}{0.661104LQRATE1} + \underset{(0.85)}{0.042978D75} - \underset{(-2.6)^*}{0.118924D82} - \underset{(-4.0)^*}{0.740941}$$

$R^2 = 0.998$; D-W = 1.7; F = 1553.0*; $RBAR^2 = 0.997$; n = 24

Figures in parentheses are t-values, and * shows significance at 1%.

3 Wage Determination

3.1 The theoretical model and its empirical variant: wage rate

The wage equation is of crucial importance in any macroeconometric model. As noted in Karingi and Ndung'u (2000), this equation should be able to capture the effects of unemployment, if it follows the Phillips curve approach, or the effects of taxes, productivity, real exchange rate, etc., if it follows the Layard-Nickell approach. In fact, with the liberalization of wage guidelines in Kenya allowing workers and employers more freedom in wage negotiation, a bargaining approach to wage determination following the work of Layard and Nickell (1985) would be appropriate. In the theory of KTMM (see

Huizinga et al. 2001), wages and prices are determined in the labour and product markets. In the labour market, demand for labour is met with supply of labour. Labour supply is determined by demographic factors, education, unemployment rate (as a proxy to the discouraged worker effect) and net real wage. The first two factors are exogenous in the model, and the latter two endogenous. Demand for labour is specified in the context of a constant elasticity of substitution (CES) production function. A bargaining model (see Huizinga et al. 2001) determines wage rate, in which prices and unemployment rate play a major role. Wages and prices also depend on each other, so that there is a wage–price spiral in the model.

Wage formation in Kenya may be viewed from at least three levels: unionized, competitive and administered. Observed wage would be a function of competition, administration and bargaining. Thus, our model may describe only a segment of the labour force in the formal sector. To be sure, it is important to establish whether bargaining really takes place or whether employers have absolute power. Assuming that bargaining actually takes place and that a successful increase, for instance in the bargaining solution, is reflected in administered wage sectors as employers avoid worker turnover and prevent unionization, a Nash bargaining solution can be found. The theory, therefore, hinges on the assumption that benefits from bargaining benefit not only those in unions, but there is a spillover effect in the rest of the formal sector.

The wage equation in KTMM is derived in the following way. The wage resulting from the Nash bargaining solution shows productivity, the fallback position of workers and total wedge determining that wage. In the model, the fallback position is considered to be proportional to average wage level and unemployment rate. An important question that arises is whether unemployment rate is the ideal fallback position. Given the large informal sector in the country, the informal sector's wage may be a better fallback position for workers. But given the scarcity of data regarding this sector, it may be difficult to obtain the sector's wage series at the empirical stage. The wedge has four components: taxes and social security paid by workers, social security contributions paid by the firm, indirect taxes in the consumer prices, and the ratio of import prices to value-added prices. The gross wage equation from this derivation is given in Huizinga et al. (2001); it is also reproduced here:

$$\hat{w} = \beta 1 \hat{p}_c + (1-\beta 1)\hat{p}_y + \hat{h} + \beta 1 \frac{\Delta s_l}{1-s_{l_{-1}}} + (\beta 1 - 1)\frac{\Delta s_f}{1+s_{f_{-1}}} - \beta 2 \Delta ur - \beta 3 ur$$

Therefore, wages are a function of consumer prices (p_c), value-added price (p_y), productivity (h), direct taxes and social security paid by workers (s_l), direct taxes, social security and pension benefits paid by the firm (s_f), and unemployment rate (ur). The estimable wage equation is thus

$$\dot{w}_t = \beta_0 + \beta_1 \dot{p}_{t,c} + \beta_2 \dot{p}_{t,y} + \beta_3 \dot{h}_t + \beta_4 \Delta\log(1+s_{t,l}) + \beta_5 \Delta\log(1-s_{t,f}) + \beta_6 ur_t + \varepsilon_t$$

The two price variables may be combined at the actual estimation stage owing to possible multicollinearity, as consumer prices are a function of value-added price. Again, if the coefficient of one price variable is known, it is possible to establish the value of the other. Therefore, it is proposed that consumer price be used in the wage equation, to lead to the following equation for actual estimation:

$$\dot{w}_t = \beta_0 + \beta_1 \dot{p}_{t,c} + \beta_2 \dot{h}_t + \beta_3 \Delta\log(1+s_{t,l}) + \beta_4 \Delta\log(1-s_{t,f}) + \beta_5 ur_t + \varepsilon_t \qquad (4)$$

One critical point to bear in mind in estimating the wage equation is that prior to 1994, under the wage guidelines that existed since the early 1970s, workers' wage increases were allowed and limited to 75% of the cost of living index. However, these wage guidelines affected unionized workers only, leaving out a large number of workers. After 1994 the wage guidelines were extensively liberalized, allowing workers and employers greater freedom in wage negotiation. This may have resulted in a new pattern of wage settlement through the different collective bargaining agreements.

3.2 Previous studies and their specification: wage rate

MEPM and MELT3 did not explicitly consider the role of taxes in wage formation as suggested in KTMM. Wage formation in MEPM is very simple. Two wage variables are identified in MEPM: average nominal wage per employee in the modern sector, and the average real wage in the government sector. Each of these variables is projected through the preceding year's inflation rate. Therefore, the growth rate of average nominal wage earning (GRAVWGE) in the model is a linear function of the preceding year's inflation rate ($CPIFL_{-1}$). The estimated equation in MEPM is given below:

$$GRAVWGE = \underset{(5.54)}{6.1742} + \underset{(3.57)}{0.2393}CPIFL_{-1} + \underset{(4.32)}{4.34}D7576 + \underset{(5.94)}{5.66}D8081$$

$R^2 = 0.8740$; $RBAR^2 = 0.8290$; D-W = 2.04; sample = 1974–1993

Figures in parentheses are t-values.

Dummy variables in the MEPM wage equation account for the many departures from the trend line. The results above indicate that the actual increase in average workers' earnings over the sample period, 1974–1993, were 24% of the cost of living increase the preceding year.

In the government sector, average real wage earning was projected in MEPM on the basis of the following estimated equation:

$$GRRAWGG = \underset{(2.89)}{6.4934} - \underset{(-7.56)}{0.6970}CPIFL_{-1} + \underset{(4.76)}{11.71}D7677 + \underset{(5.20)}{17.55}D81 + \underset{(6.54)}{22.38}D88$$

$R^2 = 0.9186$, $RBAR^2 = 0.8968$; D-W = 2.01; sample = 1974–1993

Figures in parentheses are t-values.

Unlike in the formal private sector where workers were compensated by up to 24% for increases in the cost of living index, government workers were actually penalized, as they had no compensation. The results above show that over the 1974–1993 period there was a sharp decline in average real wage in the government sector.

MELT3, on its part, adopted the Phillips curve approach, which makes wages respond to consumer prices and unemployment. The rationale for this approach is that despite the dual nature of Kenya's labour market, it is still plausible for modern sector wage inflation, especially for the more skilled labour, to respond to the level of unemployment (Keyfitz 1994). Owing to the lack of time series on unemployment in Kenya, MELT3 uses a trend labour force from which deviations of actual employment represent tightness in the labour market and, hence, are a proxy for unemployment rate. The estimated wage equations in the model follow. Modern sector wage rate in agriculture (WAG) was projected through an equation as

$$LWAG = -0.06424 + 0.45052LPCONS + 0.36338APGDPAG + 0.19173APCONS$$
$$(-0.2857) \quad (2.516) \quad (1.978) \quad (1.306)$$

$RBAR^2 = 0.29$; D-W = 2.51; sample period = 1972–1987

Where $LWAG = LOG(WAG/WAG_{-1})-BETAW*LOG((N + N_{-1})/TRENDN)$, N is employment, and BETAW was common elasticity of wage inflation to labour force trend (TRENDN) imposed on the model.

The explanatory variable $LPCONS = LOG(PCONS/PCONS_{-2})$ is the index of consumption prices (PCONS) used to measure the cost of consumption. This index was constructed as a weighted average of the domestic GDP at factor cost deflator (PGDPFC) and the goods import price deflator (PMTOT) grossed up by duties and indirect taxes. The construction of LPCONS in the model seems not to have a rationale, as the expectation would have been a divisor lagged once resulting in a percentage change variable. $APGDPAG = LOG(PGDPAG_{-1}/WAG_{-1})$ is the agricultural sector deflator relative to agricultural wage rate, and $APCONS = LOG(PCONS_{-1}/WAG_{-1})$. The agricultural wage equation results are quite poor, but they indicate a 0.45% wage compensation for agriculture workers for a 1% change in consumer price inflation.

In MELT3, modern sector wage rate in the manufacturing sector (WMFG) is given as

$$LWMFG = 0.51203 + 0.2616LPCONS + 0.26076MPCONS$$

(1.784) (3.527) (3.887)

$RBAR^2 = 0.52$; D-W = 2.35; sample = 1972–1987

Where $LWMFG = LOG(WMFG/WMFG_{-1}) - BETAW*LOG((N+N_{-1})/TRENDN)$ and $MPCONS = LOG(PCONS_{-1}*PGDPMFG_{-1}/WMFG_{-1}^2)$ is the consumption price transformed with manufacturing sector GDP deflator and wage:

Again, MELT3 failed to provide the rationale for multiplying lagged consumer prices with the deflator. The wage inflation equation for the manufacturing sector indicates an elasticity of 0.26 of wage to consumer prices. This result is much closer to the 25% compensation for the change in the cost of living index estimated in MEPM.

MELT3 also estimates a wage equation for the modern sector's services (WSERV). The key explanatory variables in this equation are consumer price and services sector GDP deflator. An elasticity of 0.38 for consumer prices, and 0.59 for services sector deflator were estimated:

$$LWSERV = 0.70554 + 0.37547LPCONS + 0.59165SPGDPSERV$$

(1.172) (1.68) (2.16)

$RBAR^2 = 0.25$; D-W = 2; sample = 1979–1987

Like in MEPM, MELT3 estimates a wage equation for government workers. A trend term was included in the government sector, because government wages (WGOVT) significantly fell throughout the estimation period. The estimated equation given below confirms the results in MEPM, though the elasticities in the two estimations are different in magnitudes, mainly owing to differences in their specification:

$$LWGOVT = 1.70433 + 0.31573LPCONS + 0.68654GPCONS +$$

(2.43) (2.12) (4.68)

$$0.2809GPGDPGOVT - 0.02222TREND$$

(1.21) (-3.192)

$RBAR^2 = 0.68$, D-W = 2.93, sample = 1972–1987

Where LWGOVT = LOG (WGOVT/$WGOVT_{-1}$)-BETAW*LOG ((N+N_{-1})/ TRENDN); wage deflated consumer prices, GPCONS = LOG($PCONS_{-1}$/ $WGOVT_{-1}$); and government sector deflator, GPGDPGOVT = LOG ($PGDPGOVT_{-1}$/$WGOVT_{-1}$).

From estimation in MELT3, government workers have been compensated for up to 32% of the consumer price inflation.

3.3 Estimation for KTMM: wage rate

Data used

The variables used in the estimation of the growth and level-based wage determination equations (with explanations of the variables) are summarized in the table 16.

Table 16. Definition of variables

Variable	Symbol for growth rate (% change)	Symbol for levels
Wage rate	WBPP	WBPI derived by forming a wage index (1982 = 100), i.e. dividing WBVY by WBNY
Consumer price	CHPP	CHPI
Value added price	VAPP derived by dividing GDPVY by GDPREAL, forming an index (1982 = 100) and then generating % changes	VAPI derived by dividing GDPVY by GDPREAL, then forming an index (1982 = 100).
Labour productivity	LBQP	LBQI derived by dividing real gross value added[1] by WBNY and creating an index with 1982 = 100
Direct taxes	SLP derived by dividing (TDGVY + CWAGEVY) by (WBVY + WGVY) and generating a growth variable	SLI derived by dividing (TDGVY + CWAGEVY by (WBVY + WGVY)
Unemployment rate	URPP derived as explained in Annex 3.1 using the various types of employment in % changes	URI derived as in the case for growth without % changes computations.

Further details of the data explaining the generation of the variables that were not initially available in KTMM are given in annex 3.1.

3.3.1 *Growth-based regression of the wage equation*

Having determined the data representing the variables in the wage equation, the next step is to estimate the growth-based equation. Initial exploration of the properties of the data using correlations matrix indicated that there was no significant problem of multicollinearity. Even at only 0.53, the expected high correlation between value-added price (VAPP) and consumer price (CHPP) is not serious. Given this low correlation coefficient between the price variables, the wage equation in growth terms was estimated. The estimated results show an insignificant role of value-added price and unemployment rate in wage determination. The estimated equation for wage determination is given below:

WBPP= 8.95 + 0.34CHPP + 0.33LBQP +0.19LBQP(-2)+ 1.66SLP – 0.10URPP –
(4.29)* (5.30)* (3.40)** (2.07)** (3.81)* (-0.82)

6.28D82 + 44.28D94
(-2.90)* (18.11)*

R^2 = 0.97; D-W = 2.94; F-stat = 80.90; J-B = 0.39 (0.82); n = 23

$RBAR^2$ = 0.96; BG = 3.33 (0.07); ARCH-LM = 0.19 (0.67); RESET = 0.42 (0.52)

Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

The expected signs were obtained from the equation. Unemployment rate (URPP) was found to be insignificant in determining wages below the 10% level. This is not a surprising outcome for both the high- and low-skilled labour categories in a labour-surplus economy. In addition, value-added price also was found to be insignificant in the model. Consumer price and labour productivity were found to be the most important factors in wage determination. The results indicate that a 1% change in consumer prices (CHPP) results in a 0.34% change in wages. Alternatively, it can be interpreted to mean that 34% of the change in consumer prices is factored in as wage compensation. This means that over the years, real wages in the formal (business) sector outside of the government have been falling. Labour productivity (LBQP) is found to be an important variable in wage determination, owing to its significance at the 5% level. Productivity increases in the short run are accommodated by a 0.33 percentage point increase in wages for every 1 percentage point rise. Price increases and labour productivity changes account for up to two-thirds of the changes in wage in the formal sector. Even labour productivity with a two periods' lag is significant in wage determination. This result differs from that in MEPM, where the actual increase in average earnings of workers has been found to be 24% of lagged consumer price inflation. However, estimating the wage equation without a lag in labour productivity leads to the same coefficient of 0.26 obtained in the MEPM model.

A significant but unexpected result in the wage equation is the role of direct taxes paid by employees (SLP). This variable was found to be significant with a value greater than unity. It means that a 1% rise in household direct taxes exerts a 2.1% positive pressure on wages. The positive sign seems to imply that unions have bargaining power that enables them to negotiate for higher pay when direct taxes rise. Alternatively, it implies that employers factor in tax increases by raising wages. A Wald test on the null hypothesis that the coefficient for direct taxes is unity was not decisively rejected. This means that the greater than unity result should not be too much of a worry. The result on the impact of direct taxes notwithstanding, the parameter estimates for the growth-based wage equation were found to be stable. The CUSUM test indicated that there was significant parameter stability at the 5% level, as the cumulative sum of the residuals over time remained within the critical boundary area. This was confirmed by the recursive residuals test, where the recursive residuals about the zero line were within the plus and minus two standard error band, except for 1994, which had actually been captured as a dummy in the estimation.

In conclusion, it needs to be pointed out that the profit rate was introduced in an ad hoc manner even though it was used in the wage employment equation; but it was found to be insignificant. This means that profits made by firms in the formal sector do not necessarily result in higher wages. However, it can be argued that these profits are already accounted for by the positive effects on wages of rises in labour productivity. In reconciling the theory with the final estimated results, only value-added price is excluded in the final equation. This, as explained earlier, was because it was insignificant in the model.

3.3.2 Level-based regression of wage determination

The growth-based (percentage change) estimated equation of wage determination provides the short-run results on the responsiveness of wage to the explanatory variables identified in the theory. However, it is important to establish the long-run relationship of the same variables. Consequently, this section provides the level-based version of the same equation.

The correlation matrix for the variables in logarithm form showed high correlation coefficients among some of the variables. This points to a possibility of a multicollinearity problem at the estimation stage. Unit root tests on the variables to test for stationarity are reported in table 17.

Table 17. Summary of unit root tests

Variable	Level with trend and drift*		Level with drift and no trend**		Integration order
	ADF	PP	ADF	PP	
LWBPI	−2.41	−2.71	−0.14	0.08	I (1)
LCHPI	−1.83	−2.24	−0.24	−0.53	I (1)
LLBQI	−1.64	−2.06	−1.72	−1.13	I (1)
LSLI	−0.17	−0.28	0.97	1.08	I (1)
LURI	−2.83	−3.18	−1.23	−1.4	I (1)

* The Mackinnon critical values for rejection of hypothesis of a unit root of level with trend and drift at 1 and 5% significance levels are −4.35 and −3.59, respectively.

**The Mackinnon critical values for rejection of hypothesis of a unit root of level with a drift and no trend at 1 and 5% significance levels are −3.71 and −2.98, respectively.

From the unit root tests above, all the variables were found to be non-stationary with integration of order one. This suggests that non-stationarity may not be a problem if it can be established that the variables are cointegrated. Cointegration analysis using the Johansen cointegration test is given in table 18.

Table 18. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
r = 0	0.79	84.86	68.52	76.07
r ≤ 1	0.74	47.22	47.21	54.46
r ≤ 2	0.33	15.05	29.68	35.65
r ≤ 3	0.19	5.34	15.41	20.04
r ≤ 4	0.01	0.22	3.76	6.65

Cointegration analysis indicates a possibility of two cointegrating vectors at the 5% significance level, and one vector at the 1% significance level. Therefore, scope exists to expand the analysis of wage determination to an error correction mechanism to incorporate the dynamics suggested by cointegration analysis. However, the current version of KTMM leaves this for further research.

The level-based equation for wage determination was estimated ignoring the dynamic relationship alluded to above and the multicollinearity[6] problem suggested by the correlation matrix. Two specifications of the equation were investigated: one with non-transformed data, and the other with variables transformed into logarithms. The former showed significance of all explanatory variables (except unemployment rate) with the right signs. However, it failed the diagnostic tests, in particular the normality and the Ramsey RESET tests. The equation with variables in log form showed better diagnostic tests, and it is the one reported below. The parameters were also found to be stable in that the residuals were within the ±5% significance band.

$$LWBPI = \underset{(-5.08)^*}{-2.92} + \underset{(12.77)^*}{0.79}LCHPI + \underset{(5.46)^*}{0.66}LLBQI + \underset{(3.00)^*}{0.39}LSLI - \underset{(-0.57)}{0.04}LURI - \underset{(-6.16)^*}{0.16}D77 -$$

[6] It is worthwhile to reiterate here that multicollinearity is mainly a data problem and is best solved with additional non-sample information. Therefore, too much concern should not be placed on the potential multicollinearity problem if there is a possibility of improving the data points or adopting another estimation technique, as noted earlier.

$0.25D93 + 0.14D94$

$(-8.78)^*$ $(4.52)^*$

$R^2 = 0.99$; $RBAR^2 = 0.99$; D-W = 1.68; F-stat = 850.96; J-B = 1.12 (0.57); B-G = 0.7 (0.51); ARCH LM = 0.02 (0.9); RESET = 1.95 (0.18); n =23

Figures in parentheses are t-values, and * shows significance at 1%.

The dummies for 1977, 1993 and 1994 were meant to capture the outliers revealed in those particular years.

Empirical results indicate that in the long run wages depend positively on price level and labour productivity—the former being the more significant of the two. An important finding is that productivity is significant in the short run—as found in the growth-based equation—and the long run. At 0.79, elasticity of wages to prices is close to 0.75, which is used as a benchmark by the government in checking the wage–price spiral. Unemployment is not a significant determinant of the wage level in the long run, just as it was not significant in the short run. A more important finding is that taxation is significant and has the right sign in the level-based equation, with an elasticity of 0.39. These long-run results will be combined with the short-run outcomes in the next stage of the model.

4 Wage Employment

4.1 The theoretical model and its empirical variant: wage employment

Wage employment in KTMM is determined from a CES production function. If such a function and the neoclassical condition for optimal input combination are given, demand for labour input (i.e., wage employment) can readily be estimated. The optimality condition entails equating the partial derivative of the CES production function (with respect to labour) with real input cost. This gives the theoretical and the estimable equations given below. Noting the impact of the performance of firms in determining the level of employment, a performance indicator (profit rate) also is introduced.

$$l^{employees} = \left(\alpha^{1+\rho}\right)^{\delta} Y \left(\frac{w}{p_y}\right)^{-\sigma} + \left(\frac{\pi}{k}\right)_{t-1}$$

Where Y is output produced, P_y is output (value-added) price, w is wage, l is labour input, and π is profit.

$$\dot{L}_t = \beta_0 + \beta_1\dot{\omega}_t + \beta_2\dot{Y}_t + \beta_3\dot{\pi}_t + \varepsilon_t \qquad (5)$$

Where ω is real wage, and all the variables are in the difference of log (growth rate).

4.2 Previous studies and their specification: wage employment

In MEPM, different categories of employment are defined, and a regression equation is estimated for each. Modern sector wage employment, which is the subject of this section, is modelled in MEPM as a demand for labour. And demand for labour is taken as a function of economic activity (represented by real GDP) and price of labour (real wage earning in the modern sector). On the basis of this, the following equation is estimated:

LnWEMPMS = 2.6024 + 0.6548*lnRGFC – 0.0251D82D84
(2.98) (10.61) (-2.13)

$R^2 = 0.994$; $RBAR^2 = 0.9929$; D-W =1.89; n = 20

Figures in parentheses are t-values, and * shows significance at 1%.

In this equation, the dummy is explained as the loss of confidence following the 1982 coup attempt, the contraction in government expenditure and the drought in the 1982–1984 period.

4.3 Estimation for KTMM: wage employment

Data used

Table 19 summarizes the respective variables used in the estimation of the growth- and level-based equations of wage employment.

Table 19. Definition of variables

Variable	Symbol for growth rate (% change)	Symbol for levels
Wage employment	WBNP	WBNY
Real wage	WBPI derived by dividing WBVY by WBNY and creating an index (1982 = 100) before getting % change	WBRP derived by dividing WBVY by WBNY and creating an index (1982 = 100)
Real GDP	GDPQP	GDPREAL
Disposable profit income	PINCP derived as a % growth variable by dividing ZDISVY by CAPVZ	PINC derived simply ZDISVY divided by CAPVZ

Note: See Annex 3.2 for an elaborated discussion of the variables used above.

4.3.1 Growth-based regression of the wage employment equation

The correlation matrix of the variables used in the growth-based wage employment equation is as shown in table 20.

Table 20. Correlation matrix of the growth-based model

	WBNP	WBRP	GDPQP	PINCP
WBNP	1			
WBRP	−0.8	1		
GDPQP	0.21	−0.03	1	
PINCP	0.24	−0.35	−0.14	1

It is evident that there is not likely to be a problem of multicollinearity, given the low correlations between the explanatory variables. The preliminary estimated equation for wage employment without any dummies for the shock observed in 1993 and 1994 is as follows:

$$WBNP = 2.45 - 0.51WBRP + 0.31GDPQP + 0.12PINCP$$

$$(3.06)^{*} \quad (-7.12)^{*} \quad (2.07)^{**} \quad (2.02)^{**}$$

$R^2 = 0.73$; D-W = 2.22; F-stat = 18.15; JB = 2.66 (0.26); n = 31

$RBAR^2 = 0.69$; BG = 0.28 (0.76); LM = 0.56 (0.46); RESET = 1.68 (0.21)

Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

The results obtained from the growth-based wage employment equation are reasonable. First, the expected signs for the explanatory variables are achieved; that is, there is a negative relationship between employment demand and wage, and a positive relationship with economic activity and profits. The magnitudes of the parameters are also acceptable and significant at 5 and 10% significance levels. A 1% rise (or fall) in wages will result in a 0.51% fall (or rise) in wage employment. Moreover, a 1% increase in economic growth would result in a 0.31% increase in wage employment demand. And as per a priori expectations, the higher the profitability of firms in the private sector, the faster the growth in wage employment. A 1% rise in previous year's profitability results in a 0.21% increase in the current period's wage employment demand. These parameters were found to be reasonably stable from the CUSUM stability test.

The results above are different from those obtained from the MEPM model. MEPM estimated elasticities of 0.65 and –0.13 for wage employment with respect to real GDP and average real wage earning in the modern sector, respectively. While these are long-run estimates, they indicate that over the sample period of the MEPM model, real GDP was more significant than cost of labour in determining wage employment. This differs from the results of the growth-based equation of KTMM, as wage emerges as the most significant factor in determining wage employment in the private (business) sector. This suggests that in making employment decisions, employers are now influenced more by cost of labour than by the performance of the economy. It must be emphasized, however, that the level of economic activity and profitability of firms are not ignored by potential employers when making employment decisions.

4.3.2 Level-based estimation of wage employment

The growth-based estimated results give an idea of the short-run responsiveness of employment demand to the identified explanatory variables as derived from the theory of the model. It is necessary to investigate the long-run relationship of demand for wage employment with the same explanatory variables. As a starting point, the data in levels for the variables in the wage employment equation are identified from the KTMM database.

The level-based equation for wage determination is estimated in logarithmic form, so the correlation and unit root properties of the variables in their logarithms were established first. The correlation matrix is shown in table 21.

Table 21. Correlation matrix of the variables in levels

	LWBNY	LWBR	LGDPREAL	LPINC
LWBNY	1			
LWBR	0.43	1		
LGDPREAL	0.97	0.56	1	
LPINC	–0.08	–0.22	–0.28	1

The unit root tests in table 22 indicate that all the levels variables in their logarithms are non-stationary and were all established to be I(1). The Johansen test procedure for cointegration was then used to determine the number of cointegrating vectors. The results are shown in table 23.

The cointegration test (table 23) shows a possibility of two cointegrating vectors at the 5% level of significance and one at the 1% level. This implies that there is need for dynamic analysis for wage determination. However, dynamic analysis will be carried out in the future work on the model: what is reported below is the long-run relationship of the theoretically based wage employment equation.

Table 22. Summary of unit root tests

Variable	Level with trend and drift*		Level with drift and no trend**		Integration order
	ADF	PP	ADF	PP	
LWBNY	–2.62	–3.92	–0.08	–0.34	I(1)
LWBR	–3.68	–3.57	–2.43	–2.7	I(1)
LGDPREAL	–2.37	–1.55	–1.12	–1.42	I(1)
LPINC	–0.55	–1.58	–0.76	–2.03	I(1)

* The Mackinnon critical values for rejection of hypothesis of a unit root of level with trend and drift at 1 and 5% significance levels are –4.35 and –3.59, respectively.

** The Mackinnon critical values for rejection of hypothesis of a unit root of level with a drift and no trend at 1 and 5% significance levels are –3.71 and –2.98, respectively.

Table 23. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
r = 0	0.793	77.15	47.21	54.46
r ≤ 1	0.652	39.34	29.68	35.65
r ≤ 2	0.439	14.02	15.41	20.04
r ≤ 3	0.005	0.13	3.76	6.65

As can be seen from the diagnostic tests, the estimated equation has a very poor Ramsey RESET statistic in spite of its better outcome for other tests. However, this was the best specification of the equation that could be obtained:

$$LWBNY = -4.81 - 0.41LWBR + 0.80LGDPREAL + 0.11LPINC_{(-1)} + 0.07D9398$$
$$(-16.80)^{*} \quad (-5.14)^{*} \quad (15.94)^{*} \quad (2.38)^{**} \quad (2.62)^{**}$$

$R^2 = 0.99$; D-W = 1.52; F-stat = 486.13; J-B = 0.94 (0.62); n = 25; $RBAR^2 = 0.99$; BG = 0.58 (0.57); ARCH LM = 0.27 (0.61); RESET = 22.21 (0.0002)

Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

The wage employment equation in levels implies that economic activity as captured through real GDP is the one that matters in the long run as opposed to the short-run results in which wage rate is the key determinant. The long-run results above are consistent with those of the MEPM model. As previously noted, in terms of magnitude, MEPM estimated long-run elasticities of 0.65 and –0.13 for wage employment with respect to real GDP and average real wage earning, respectively.

5 Private Investment

5.1 The theoretical model and its empirical variant: private investment

Private investment in KTMM is specified in the context of a CES production function that has labour and capital as its arguments. The labour component, as shown in the previous chapter, provides the equation used for estimating the level of employment (that is, demand for labour). The capital component, which is the subject of this section, provides us the equation needed to estimate private investment.

First, optimal macro capital stock is determined (see Huizinga et al. 2001). The growth version is then derived. Noting the importance of profits as financial instruments (of self-financing) and the importance of the capacity utilization rate as an indicator of the gap between actual and optimal capacity, these two terms are introduced on an ad hoc basis. This has resulted in the theoretical equation and its estimable variant given below:

$$\frac{i}{k_{-1}} = \hat{y} - \sigma(\hat{p}_k - \hat{p}_y) + \delta + \lambda\left(\frac{\pi}{k}\right)_{t-1} + \mu(q - 1)$$

$$= \hat{y} - \sigma(\hat{p}_i - \hat{p}_y) - \sigma\frac{dr}{r + \delta + \bar{r}} + \delta + \lambda\left(\frac{\pi}{k}\right)_{t-1} + \mu(q - 1)$$

Where k = capital stock, p_k = price of capital, π = profits, p_y = value-added price, δ = depreciation, q = capacity utilization, and y = output.

$$\left(\frac{I_t}{K_{t-1}}\right)_t = \beta_0 + \beta_1 \dot{Y}_{tt} + \beta_2 \dot{P}_{tt} + \beta_3 \dot{P}_{y_t} + \beta_4 \dot{\pi}_{t-1} + \beta_5 q_t + \varepsilon_t$$

The constant term β_0 is an aggregate term that captures the effect of depreciation and change in real interest rate. This would simplify estimation. It is also possible to explicitly incorporate real interest rate at the estimation level to see its plausibility. Since the depreciation rate is usually a rough estimate, capturing it by the constant is the best approach.

5.2 Previous studies and their specification: private investment

Determinants of private investment are analysed using a variety of theories. The accelerator, the Tobin-q and the user cost neoclassical model are the basic models upon which much of the investment analysis is based. Within the African context, application of the Tobin-q model is limited, since capital markets in the continent remain extremely rudimentary. This dearth of information is also reported in Kenya (Soderbom 1998: 110). Thus, the competing models in this analysis are Jorgenson's user cost and a modified accelerator model that incorporates the specificity of African economies. Jorgenson's user cost is difficult to employ in Africa, partly as a consequence of data problems. Moreover, the model assumes substitution between the factors of production—a not so plausible assumption in developing countries, where foreign exchange constraints are pervasive.

Results of studies on developing countries (see Agénor and Montiel 1996) point out that aggregate demand, relative factor prices, credit variables, indicators of foreign exchange availability, public investment and indicators of macroeconomic stability are important determinants of private investment in these countries.

Most empirical works in the least developed countries (LDCs) also are based on the accelerator model. One such model, which has been modified to accommodate the external constraint to private investment in developing countries, is that of FitzGerald et al. (1992).[7] The estimable equation of this model sets private investment as a function of change in GDP, public investment, imports, capital flight and imports.

There have been several efforts to model investment in Kenya. MEPM divides investment into fixed and inventory components. The fixed component is further divided across institutions (private, government, parastatal and traditional, and private investment constitutes more than 50% of the total fixed investment in Kenya). Estimation is done for each of these. Our focus here is on the estimated equation of private investment. In this model, private investment is assumed to be determined by expectation of profit. Various proxies for profit are attempted. This list includes GDP growth, export earnings and real exchange rate. Moreover, the level of import (or the level of foreign exchange reserves), yields on government bonds (as cost of finance) and availability of credit also are taken as explanatory variables. After running regression equations with the variables listed above, the following equation is chosen and used in the model:

$$\underset{}{LnPrinv} = \underset{(-1.96)}{0.2998} + \underset{(4.71)}{0.5008 \ln rxt_{t-1}} + \underset{(3.11)}{0.2319 \ln frm_{t-1}} + \underset{(2.82)}{0.2307 \ln arpcd} +$$

$$\underset{(2.61)}{3.6854 \ln(RGDP_{t-1}/RGDP_{t-2})} + \underset{(4.48)}{0.2238D81} - \underset{(-5.25)}{0.2849D84} - \underset{(-3.07)}{0.1609D86}$$

$R^2 = 0.9307$; $RBAR^2 = 0\ 8866$; D-W = 2.36; n = 18

Figures in parentheses are t-values.

Where Prinv = private investment, rxtl = real export of goods, rfrm = ratio of foreign exchange reserve to imports, and arpcd = commercial bank credit to the private sector deflated by price index of capital goods.

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[7] The work of FitzGerald et al. (1992) is extended by inclusion of other relevant variables and its formulation in an error correction model in Alemayehu (forthcoming).

In MELT3, real investment spending is estimated for each of the production sectors specified in the model (traditional, agriculture, manufacturing, services and government). Summing up such sectoral values gives total investment. The specification is fairly standard across sectors and it follows a simple accelerator type model. The main variables used as explanatory variables are real GDP and real sectoral capital stock. The authors noted that they could not get empirical justification for including interest rate in their model. The coefficients obtained for GDP for the sectors are 0.1 for traditional, 0.04 for agricultural, 0.32 for manufacturing, 0.21 for services and 0.70 for government. The capital stock variable is found to have invariably negative coefficients that range from –0.003 (for the government sector) to –0.32 (for manufacturing).

A study based on micro (firm) level data for the manufacturing sector in Kenya also shows that the propensity to invest is positively related to firm size and retained earnings (own finance). The latter is the primary source of funding, accounting for over 60% of the finances of organized firms, and for more than 80% for unorganized (informal) firms. This finding casts doubt on the idea that poor access to finance is a binding constraint (see Soderbom 1998).

5.3 Estimation for KTMM: private investment

Data used

Table 24. Definition of variables

Variable	Symbol for growth rate (% change)	Symbol for levels
Real GDP	GDPQ	GDPREAL
Real investment	IBQP	Derived [IBVY/IPI)]100
Investment price	IPP	IPI
Consumer price	CHPP	CHPI
Disposable profit income	Derived [lnProfit-lnProfit(-1)] Also: ZDISVY/CAPVZ	ZDISVY
Real public investment	IGQPY	IGQY
GDP deflator	GDPDEFP: Derived [GDP real/GDP nominal)	GDPDEf

5.3.1 Growth-based regression

The correlation matrix (table 25) shows that the explanatory variables are not so highly correlated as to cause a high degree of multicollinearity. The only strong correlation coefficient is for profit and capacity utilization rate. Estimation leaving out one of these variables is made to see if multicollinearity caused by this is large. Leaving out one of these variables renders the other statistically stronger (see the equations below).

Table 25. Correlation matrix of the growth-based regression

	IBQP	GDPQP	CHPP	Profit rate	QRATE	INTREAL	IPP
IBQP	1						
GDPQP	0.54	1					
CHPP	−0.33	−0.53	1				
PROFITRATE	0.19	−0.06	0.31	1			
QRATE	0.01	−0.34	0.4	0.68	1		
INTREAL	−0.07	−0.15	−0.33	−0.07	−0.06	1	
IPP	−0.25	−0.17	0.13	−0.04	0.17	0.03	1

Initial estimation of this model relies on the use of capacity utilization and leaves out the impact of profit. This estimation is then extended by explicitly taking into account the impact of profit, as well as public investment. Moreover, value-added price is used instead of consumer price, which is used as a proxy in the previous estimation.

Estimation of the growth-based estimation is found to be the most difficult one, giving conflicting diagnostic test values (especially a trade-off between normality and specification tests). Profit rate also shows an unexpected negative coefficient. In the growth-based equation below, we have reported estimation results with and without profit.

Another interesting feature that emerged in the course of estimating this equation relates to the impact of public investment. Various levels of lag (from current to five-year lags) are experimented with. Only the current and five-year lagged values are found to have statistically significant (and positive) effect. When public investment was lagged by one, two and four periods, it resulted in negative but statistically insignificant coefficients. The lag level of three years also showed a statistically insignificant but positive coefficient. The conclusion that could be drawn from this result is twofold. First, the current level of public investment (probably owing to a demand effect) and public investment five years back (probably owing to infrastructure impact) have brought about a crowding-in effect in Kenya. Second, there is need to disaggregate public investment data into infrastructure and other investment components and further examine the crowding-in/out hypothesis.

Without profit rate

$$IBQP = 28 + 2.202502GDPQP - 0.917755^{*}IPP + 1.875401GDPDEF -$$

(3.48)** (3.42)* (-2.61)* (2.97)*

$$0.016841INTREAL + 0.424304IGQPY + 0.352718IGQPY(-5) +$$

(-0.08) (5.01)* (4.77)*

$$13.8D93T97 + 37.97D87$$

(2.11)** (12.2)*

$R^2 = 0.83$; D-W =2.03; J-B =1.03 (0.68); BG = 0.52 (0.60); RBAR^2= 0.74; F = 9.5*;
RESET =1.93 (0.19); LM = 0.08 (0.77); n = 23

Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

With profit rate

$$IBQP = 26 + 2.86755GDPQP - 1.583756IPP + 1.972803GDPDEF -$$

(1.2) (3.69)* (-3.621)* (2.02)*

$$0.531821INTREAL + 0.390016IGQPY + 0.249014IGQPY(-5) -$$

(-1.63)*** (4.1)* (3.13)*

$$1.844468PROFITRATE + 26.14D93T97$$

(2.0)** (2.5)*

$R^2 = 0.81$; D-W = 2.7; J-B = 1.76 (0.41); BG = 1.83 (0.2); RBAR^2= 0.71; F = 7.7*;
RESET = 1.09 (0.31); LM = 1.12 (0.30); n = 23

Figures in parentheses are t-values, and * and *** show significance at 1 and 10%, respectively.

Note

*[**] [***] = significant at 1, [5] and [10]%, respectively; values in parenthesis are t-statistics for coefficients and P-values for J-B, BG, RESET and LM where J-B = Jarque Bera normality test; BG = Breusch-Godfrey serial correlation test; RESET = Ramsey's specification test; ARCH LM = heteroschedasticity.

The growth-based estimation above has statistically significant and theoretically plausible results. At the exploration stage, dummies for 1986, 1987 and 1993–1997 are found to have statistically significant impact and as a result are included. The 1993–1997 period is the aftermath of the 1992 elections and the financial scams in the Central Bank (see Ndung'u and Ngugi 1999: 467). Almost all major macro variables deviate from the norm in 1993. It was the year when inflation jumped from 27 to 46%, the treasury discount rate from 16.8 to 48.2%, and the Kenya shilling exchange rate to the US dollar from Ksh 36.22 to 68.16, and when the floating rate was introduced (Ndung'u and Ngugi 1999: 465–469). At the exploration stage, we have estimated a number of equations resulting in statistical trade-off between the specification (RESET) and normality tests. The models reported above are the most preferred in terms of balancing these diagnostic test results.

5.3.2 Level-based regression

Table 26. Correlation matrix of the level-based regression

	LIBQPLEVEL	LGDPREAL	LIPI	LCHPI	LZDISQY	QRATE	INTREAL
LIBQPLEVEL	1	0.41	0.33	0.34	0.38	–0.39	0.14
LGDPREAL	0.41	1	0.98	0.97	0.88	–0.04	0.59
LIPI	0.33	0.98	1	0.99	0.88	0.13	0.6
LCHPI	0.34	0.97	0.99	1	0.9	0.19	0.55
LZDISQY	0.38	0.88	0.88	0.9	1	0.17	0.49
QRATE	–0.39	–0.04	0.13	0.19	0.17	1	–0.06
INTREAL	0.14	0.59	0.6	0.55	0.49	–0.06	1

Table 27. Summary of unit root tests*

Test	LGDREAL	LIBQPLEVEL	LIPI	LGDPDEF	Profit rate	TBRY	LIGY
ADF	–1.22	–2.89	–1.78	0.05	–0.94	–1.93	–1.94
PP	–1.44	–3.15	–1.63	0.19	–2.3	–2.51	–2.1

* 1 and 5% levels of significance for both tests are –3.73 and –2.99, respectively

Table 28. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
r = 0	0.94	153.3	124.15	133.57
r ≤ 1	0.77	88.1	94.15	103.18
r ≤ 2	0.62	54.43	68.52	76.07
r ≤ 3	0.48	32.4	47.21	54.46
r ≤ 4	0.34	17.37	29.68	35.65
r ≤ 5	0.25	7.7	15.41	20.04
r ≤ 6	0.04	0.88	3.76	6.65

The Johansen test above suffers from an inadequate sample size, as we have only 23 data points. Despite this data problem, the trace test (table 28) shows the possibility of one cointegrating vector at 1% level of significance. Leaving aside the dynamic analysis, which will be dealt with in future work, we report the long-run relationship that is based on the theoretically imposed specification:

LIBQPLEVEL = -25.02468 + 3.118623LGDPREAL – 1.57136LIPI +
(-11.6)* (12.7)* (-8.5)*

0.010273LGDPDEF – 0.004652INTREAL + 0.438159PROFITRATE(-1) +
(0.05)* (-5.3)* (3.8)*

0.306186LIGQY + 0.390945LIGQY(-5) + 0.56916D9397 – 0.202113D86
(11.3)* (12.9)* (7.2)* (-5.4)*

R^2 = 0.99; D-W = 2.4; J-B = 0.64 (0.72); BG = 2.4 (0.15); n = 20
RBAR^2= 0.97; F = 72.9*; RESET = 0.08 (0.77); LM = 0.69 (0.42)
Figures in parentheses are t-values, and * shows significance at 1%.

The estimation result is very good in terms of diagnostic tests, except for a possible serial correlation. One major problem, however, is the coefficient of LGDPDEF, which, despite having the right sign, is very low and statistically insignificant. Use of LCHPI as an instrument could not improve the results either. One striking distinction between the growth- and level-based estimations is impact of profit. The profit rate is found to have a negative coefficient in the short run and to be statistically insignificant in some versions of the equation. However, in the long run it has a strong and positive impact. The possible reasons for the counter-intuitive result in the short run are, first, the sharp drift in profit rate in the whole of the 1980s and, second, the rising profit in the early 1990s, which must have diverted to the financial sector as a result of liberalization and lucrative and quick return in the financial market at the expense of capital formation in real sectors. Our result may also point to the importance of persistent profit (long run) as opposed to short-run profit in inducing capital formation.

6 Import Demand

6.1 The theoretical model and its empirical variant: imports

Kenya has a very open economy; as a result, the properties of trade equations are key elements in determining the nature of any balance of payments constraint in a macroeconometric model. One such equation is demand for imports. In KTMM, gross output is a constant elasticity of substitution aggregation of value added and imports. Consequently, demand for imports is theoretically a function of output and relative prices. This makes the scale variable and price elasticity the key variable and parameter, respectively, in the import demand equation. As shown in Huizinga et al. (2001), the scale variable is simply the growth of gross output in the economy weighted by the importance of the various components of the final demand. Working through the derivations in the KTMM theory paper (Huizinga et al. 2001), the percentage change in imports due to output effects, assuming constant import shares (that is, constant relative prices), is given as

$$\hat{m} = \hat{z}_m = \left(\frac{m_c}{m}\right)_{-1}\hat{c} + \left(\frac{m_i}{m}\right)_{-1}\hat{i} + \left(\frac{m_g}{m}\right)_{-1}\hat{g} + \left(\frac{m_x}{m}\right)_{-1}\hat{x}$$

Adding the relative price effect results in an import demand function of the form shown as

$$\hat{m} = \hat{z}_m - \sigma(\hat{p}_m - \hat{p}_y)$$

Where $\hat{p}_m$ is the percentage change in price of imports in shillings, $\hat{p}_y$ is the percentage change in value-added price, and σ is the elasticity of substitution between domestic value added and imports. Subscripts c, i, g and x to m (imports) show consumption, investment, government and export sectors, respectively.

Elasticity of imports with respect to the scale variable is not always unity, and in empirical studies this is explained by a trend towards internationalization. Therefore, the import demand equation needs to capture the internationalization phenomenon, resulting in the following import demand function for KTMM:

$$\hat{m} = \alpha\hat{z}_m - \sigma(\hat{p}_m - \hat{p}_y)$$

Where $\alpha \geq 1$ is the parameter capturing internationalization.

The estimable import demand equation in the model is then derived as

$$\dot{m}_t = \beta_0 + \beta_1\dot{z}_{t,m} + \beta_2\dot{p}_{t,m} + \beta_3\dot{p}_{t,y} + \varepsilon_t \qquad \beta_1 \geq 1; \beta_2 < 0; \beta_3 > 0; \beta_2 = \beta_3 \quad (7)$$

Which, when simplified to have one relative price variable, and with GDP as the scale variable, becomes

$$\dot{m}_t = \beta_0 + \beta_1\dot{z}_{t,m} + \beta_2(\dot{p}_{t,m} - \dot{p}_{t,y}) + \varepsilon_t \qquad \beta_1 \geq 1; \beta_2 < 0$$

Price of imports (p_m) in the above equation is given by exogenous price of imports in foreign currency (p_m^S), exchange rate (e) and import tariff rate (t_m), that is

$$\dot{p}_{t,m} = \dot{p}_{t,m}^S + \dot{e} + \frac{\Delta t_{m_t}}{1 + t_{m_{t-1}}}$$

The formulation of the import demand functions presupposes that imports are disaggregated by end uses. As shown below, both MELT3 and MEPM were developed at a time when the exchange rate regime was changing to become flexible after being controlled by government authorities. This meant that the exchange rate was not a significant variable in the import demand equations in these models, but availability of foreign exchange was significant. The major weakness with this formulation is that it ignores the role of real exchange rate. But the exchange rate is an important variable in determining the level of trade in an open economy like Kenya's. Consequently, an attempt can be made to explain imports in the Kenyan economy through real exchange rate.

The impacts of monetary and fiscal policies and their influence on real exchange rate, and hence on the balance of payments, would be captured with this kind of formulation. It can also be seen that inclusion of import price in the estimable import equation effectively specifies imports as a function of real exchange rate. Inclusion of exchange rate is quite important in Kenyan conditions, because the increasing liberalization of the economy means that what happens in the foreign exchange market (as opposed to the level of reserves, which were important in controlled regimes) is crucial in determining the level of imports.

6.2 Previous studies and their specification: imports

In MEPM, demand for imports is modelled beginning with the general formulation that imports are a function of income, price, official control on imports and a dummy variable. However, MEPM has no aggregate import demand equation, as such. The model estimates regression equations for four groups of SITC categories, SITC 0 and 1, SITC 2 and 4, SITC 3, and SITC 5 to 9, as usually reported in the *Economic Survey* and *Statistical Abstract*. Therefore, unless the KTMM import demand equations were to be disaggregated by SITC categories to the MEPM level, they may be incomparable with those of MEPM. Indeed, it is important to note that the theory behind import demand in KTMM is different from the one used in MEPM. Rather than using SITC classification, the import-demand equations of KTMM use end-use analysis of imports. There might be a difference in the two models to the extent that SITC classification differs from end-use classification.

MEPM regression equations[8] for the various SITC categories of imports are reported below. The estimations are based on data for 1978–1993. The import-demand equation for food and live animals (SITC 0) and beverages and tobacco (SITC 1) was

$$\ln RM01 = \underset{(3.72)}{7.6039} + \underset{(3.10)}{0.9690}\ln RGPFC_{-1} - \underset{(-3.66)}{0.8953}\ln TARPM01 - \underset{(-4.55)}{0.9757}\ln QCRL +$$

$$\underset{(2.43)}{0.4443}D82 + \underset{(4.34)}{0.4124}D84T87 + \underset{(3.47)}{0.6118}D90 + \underset{(3.04)}{0.5546}D92$$

$R^2 = 0.8776$; $RBAR^2 = 0.7727$; D-W = 2.45; sample = 1978–1993

Figures in parentheses are t-values.

RM01 is the quantity of imports. The import-demand equation above uses the general specification, with real GDP (RGPFC) as the demand variable and the tariff-adjusted relative price of imports (TARPM01) for SITC 0 and 1 as the price variable. QCRL is a variable representing domestic production of two major cereals—maize and wheat—as an indicator of the need for imports. The four additional dummies in the equation take account of the large quantities of imports of wheat (in 1982 and 1985–1987), maize (in

[8] Several equations are estimated for each SITC category. For brevity, only equations that are eventually employed in projections are shown here.

1985 and 1990), and sugar (in 1992). These were related to the political disturbances of 1982, the droughts of 1984–1985 and 1989–1990 and the problems with the sugar industry since 1991. The signs of the coefficients are right, and the estimated elasticities are theoretically plausible.

In the import demand for crude materials and inedible (SITC 2), animal and vegetable oils (SITC 4), the explanatory variables tested in determining the equation for the model included overall GDP, industry GDP and tariff-adjusted price of imports for these categories. The preferred equation for the sample period 1973–1993 was

$$\ln RM24 = \underset{(0.33)}{0.2559} + \underset{(15.82)}{1.0454}\ln RGPIN_{-1} - \underset{(-5.02)}{0.6027}\ln TARPM24 + \underset{(3.78)}{0.3477}D74 + \underset{(3.15)^{*}}{0.2766}D77 - \underset{(-2.63)}{0.2235}D79$$

$R^2 = 0.9585$; $RBAR^2 = 0.9448$; D-W = 2.11; sample = 1973–1993

Figures in parentheses are t-values, and * shows significance at 1%.

The equation above provides a good explanation for import demand for SITC 2 and 4, RM24, by industry GDP (RGPIN), respective import prices (TARPM24) and the dummies accounting for the oil price shock of 1973–1974 and the coffee boom of 1976/77. The estimated elasticities have the expected signs and plausible magnitudes. In particular, the estimate of elasticity coefficient for the industrial GDP variable is not significantly different from the theoretically expected value of unity.

The other import demand equation in MEPM was for SITC 3, which comprises mineral fuels, lubricants and other related materials. The estimated equation used in the model for these imports was based on the 1973–1992 sample period and was as follows:

$$\ln RM3 = \underset{(3.27)^{*}}{2.1700} + \underset{(2.69)^{**}}{0.1815}\ln RGPIN_{-1} - \underset{(-3.95)^{*}}{0.1245}\ln TARPM3 + \underset{(8.70)^{*}}{0.4449}\ln AQXFL +$$

$$0.2549D7480 + 0.1211D90$$
$$(7.64)^{*} \qquad (2.62)^{**}$$

$R^2 = 0.9565$; $RBAR^2 = 0.9410$; D-W = 1.65; sample = 1973–1992

Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

A low-price elasticity is obtained for SITC 3, and this is explained by the fact that oil is a necessity for both consumption and production. On the other hand, the low elasticity for industrial GDP is probably due to the fact that oil consumption is related more to the size of the plant than to the level of output (MEPM 1994).

The last import-demand function used in MEPM is an aggregation of SITC categories 5 to 9: chemicals (SITC 5), manufactured goods classified by materials (SITC 6), machinery and transport equipment (SITC 7), and miscellaneous manufactured articles (SITC 8 and 9). As stated in MEPM, to obtain the best explanatory equation for this category, choice had to be made among three activity variables: total GDP, industrial sector GDP and level of investment. The equation chosen for the model was the one that had level of investment as the activity variable. This was because for the most recent years in the sample period 1973–1992, both real imports in SITC categories 5 to 9 and real investment had shrunk, and both overall GDP and industrial sector GDP had grown at decelerating rates. The estimated equation for import demand in this category (RM59) was

$$\ln RM59 = 1.5834 + 1.0850 \ln RINVM - 0.4625 \ln TARPM59 + 0.2818D74 -$$
$$(1.70) \qquad (8.10) \qquad (-8.14) \qquad (3.09)$$

$$0.2380D81T83$$
$$(-4.73)$$

$R^2 = 0.9249$; $RBAR^2 = 0.9061$; D-W = 1.95; sample = 1973–1992

Figures in parentheses are t-values.

The specification of the model above resulted in low price elasticity for imports compared with the elasticities achieved with overall GDP

(–1.7981) and industrial GDP (–1.4823). The low elasticity is expected, since in Kenya investment in fixed capital formation outside the traditional economy is highly import intensive (GoK 1994). The two dummy variables in the estimated equation account for the blip in imports in 1974, which was mainly due to demand for stock building following the oil crisis of 1973. The years 1981–1983 were marked by low imports in these categories as a result of the second oil crisis in 1979 and the political turmoil of 1982 and its aftermath.

In modelling trade, MELT3 uses the key small-country assumption and, hence, the price-taking nature of Kenyan traders. Imports are set as a function of relative prices and domestic income. Three categories of imports are estimated: merchandise (or visible) imports, which are divided into oil (MOIL) and non-oil (MNOIL) imports, and one category of services (MS). The resulting equations in MELT3 for these categories are presented here. For real oil imports (RMOIL):

$$\underset{(1.602)}{RMOIL = 288.292} + \underset{(2.014)}{0.31917RMNOIL} + \underset{(2.157)}{0.47638RGDPFC} -$$

$$\underset{(-1.962)}{67.7057FXREALR} + \underset{(4.564)}{64.377LOG(TREND)} + \underset{(4.86)}{73.6434D7480}$$

$RBAR^2 = 0.80183$; D-W = 2.13; sample = 1972–1987

Figures in parentheses are t-values.

Where net oil imports for domestic consumption, $RMNOIL = RMOIL_{-1}\text{-}RXOIL_{-1}$, and RGDPFC is a two-period moving average of nominal output deflated by the duty (RDUTYOIL) inclusive import price of oil (PMOIL), that is, $RGDPFC = GDPFC/ (PMOIL*(1 + 0.01*RDUTYOIL)) + GDPFC_{-1}/(PMOIL_{-1}*(1+0.01*RDUTYOIL_{-1}))$

Foreign reserves were not significant in this equation. Oil imports appear fairly price inelastic, especially in the short term, but real foreign exchange rate ($FXREALR = LOG\ (FXREAL+FXREAL_{-1})$), with its negative coefficient, increased the price responsiveness of the equation.

Import demand for real non-oil goods in MELT3 (RMNOIL) depends on real domestic output (RGDPFC) and relative prices of imports and domestic output (PMNOIL*(1+0.01*RDUTYOIL)/PGDPFC). Foreign exchange constraints[9] are captured through $FXRESERVES_{-1}$/PMNOIL. The estimated equation in this case was

RMNOIL = -227.675 + 0.31299RGDPFC – 980.633RPMNOIL +
(-1.571) (5.959) (-6.588)

0.82251FXRESERVESR
(3.222)

$RBAR^2$ = 0.82657; D-W = 2.64; sample = 1972–1990

Where RPMNOIL = LOG (PMNOIL*(1+0.01*RDUTYNOIL)/PGDPFC) and FXRESERVESR = $FXRESERVES_{-1}$/PMNOIL*100

Lastly, in MELT3, service imports (RMS) depend on the level of domestic output divided by the price deflator for services imports (GDPFC/PMS), real goods trade (RXTOT+RMTOT)—to capture shipping—and real foreign exchange reserves ($FXRESERVES_{-1}$/PMS)— to account for foreign exchange constraints. The estimated import-demand equation for services is given as

RMS = -251.574 + 4.68995TGDPFC + 0.0575RTOT + 22.264FXRESERVESS

(-2.143) (2.653) (2.013) (1.551)

$RBAR^2$ = 0.74; D-W = 1.79; sample = 1972–1987

Where TGDPFC = (GDPFC+$GDPFC_{-1}$)/(PMS+PMS_{-1}); real goods trade variable, RTOT = (RXTOT+RMTOT+$RXTOT_{-1}$+$RMTOT_{-1}$); FXRESERVESS = $FXRESERVES_{-1}$/PMS; RXTOT is total exports, including coffee, tea, oil and other

[9] The foreign exchange constraint was used in MEPM to capture import-licensing restrictions. This was proxied by the ratio of year-end foreign exchange reserves to merchandise imports for the preceding year. However, while this variable came out with the expected sign, it had a poor t-ratio, and the overall fit of the equation was poor for SITC 0 and 1.

export types; RMTOT, on the other hand, is the aggregation of oil and non-oil imports.

One of the recent and detailed studies on imports is by Mwega (1993), who specified real demand for imports as a function of real income, relative prices, availability of foreign exchange (both current and lagged) and lagged level of imports. This model is estimated for the period 1964–1991. The estimation is done after the I(1) nature of the series and their cointegration property (using the Engel-Granger two-stage estimation approach) are examined. Mwega used this model for estimating five categories of imports and one aggregate import function.

The aggregate[10] import model shows that in the short run the two-period lagged value of foreign exchange availability and the lagged level of imports have a statistically significant effect. In other interesting results of the model, relative prices were found to be insignificant, and the strongest effect came from real income (Mwega 1993: 401). The error-correction term also is significant, although its coefficient of near unity suggests almost an instantaneous (one-period) adjustment.[11]

6.3 Estimation for KTMM: imports

Data used

- *Real GDP* (GDPQ for growth and GDPREAL for level-based estimation).

[10] For brevity, our discussion will focus on aggregate import, which is comparable to KTMM.

[11] This pattern is not seen in the individual import function, except for mineral fuels and lubricants. Excluding this from Mwega's aggregate might have given adjustment coefficients that are less than one.

- *Real exchange rate (RERSI)* is computed using nominal exchange rate (KSRDY), an index of world trade price in US dollars generated using WDPP, and consumer price index (CHPI). Growth in real exchange rate is derived from RER$I and denoted by RER$P.

- *Real imports (RMQY)* are generated using MVY and MPI for levels and MQP for growth.

- *Other variables.* The relative price of imports (RMPI) is used separately to compare the result with similar studies in Kenya (see Mwega 1993). For the growth-based model, the relative price growth is generated from RMPI and denoted by RMPIP. We do not have complete data on general reserves and net foreign reserves; however, this is an area that needs to be explored, in particular to explain the preliberalization period.

6.3.1 Growth-based estimation for imports

The correlation matrix (table 29) shows that the explanatory variables are not highly correlated. Using this information, the growth-based estimation was estimated initially without the real level of net foreign assets held by monetary authorities. That model showed a problem of misspecification. This, however, is resolved when we include net foreign asset holding. This is sensible when the import-compression period of the 1980s is taken into consideration.

Table 29. Correlation matrix: import demand equation (in growth rates)

	MQP	GDPQP	RMPP	NFASSETRP
MQP	1			
GDPQP	0.43	1		
RMPP	–0.48	–0.09	1	
NFASSETRP	0.31	–0.17	0.12	1

The result of this regression is reported below. All values are in real terms and are deflated by import price index, except GDP, which has its own deflator. All the diagnostic tests are excellent, and the parameters are stable, and they predicted the actual values very well.

$$MQP = 1.79714GDPQP - 0.64449RMPP + 0.09294NFASSETRP -$$

(4.8)* (-2.6)* (3.5)*

$$13.73156D79T83$$

(-2.8)

$R^2 = 0.7$; D-W = 2.3; J-B = 0.31 (0.85); BG = 0.98 (0.39); n = 24

$RBAR^2 = 0.65$; F = 15.4*; RESET = 0.08 (0.78); LM = 0.08 (0.78)

Figures in parentheses are t-values, and * shows significance at 1%.

6.3.2 Level-based regression

Table 30. Correlation matrix: import demand equation

	LRMQY	LGDPREAL	LRMPI	LNFASSETR
LRMQY	1			
LGDPREAL	0.45	1		
LRMPI	–0.49	0.48	1	
LNFASSETR	0.57	–0.01	–0.57	1

Table 31. Summary of unit root tests*

Test	LRMQY	LGDREAL	LRMPI	LNFASSETR
ADF	–0.75	–1.22	–2.02	–2.07
PP	–0.88	–1.44	–1.85	–1.85

* 1 and 5% levels of significance for both tests are –3.73 and –2.99, respectively.

Table 32. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
r = 0	0.76	54.73	47.21	54.46
r ≤ 1	0.5	21.49	29.68	35.65
r ≤ 2	0.22	05.74	15.41	20.04
r ≤ 3	0.0002	0.005	3.76	6.65

Tables 31 and 32 show the time series properties of the variables used in the import demand equation. The results show that all series are non-stationary in levels and follow an I(1) process. The cointegration test using 1% suggests one possible cointegrating vector that marginally passes the 5% test. Mwega (1993) was also confronted with similar boarder cases using rather large data points. We have assumed that a cointegration relation exists, and estimated the long-run values based on the theoretical specification. This result is reported below:

LM2VN = 8.54780 + 0.58982LGDPREAL – 1.09537LRMPI – 0.19758D8286 +
(7.9)* (3.8)* (-4.6)* (-2.96)

0.261832D93T97
(3.01)*

R^2 = 0.92; D-W = 2.1; J-B = 0.33 (0.84); BG=1.4 (0.26); n = 25
RBAR^2= 0.9; F = 56.7*; RESET = 0.44 (0.51); LM = 0.003 (0.96)
Figures in parentheses are t-values, and *shows significance at 1% level.

The level-based estimation shows that all the variables have the theoretically expected signs in the long run. The net foreign asset held by monetary authorities became insignificant in the level-based estimation, perhaps indicating that this variable is important only in the short run.

7 Employment in the Informal Sector

Employment in the informal sector is specified to be determined by earnings in the informal sector, earnings in other sectors of the economy (earnings in the formal sector used as a proxy), previous levels of employment in the informal sector, and labour productivity. Wage rate for the business sector is used to represent earnings in the formal sector. Data for earnings in the informal sector are not provided for in KTMM (therefore, they are not included in the regressions). However, we propose that minimum wage rate be used as a proxy for this. Given below is a description of the data used in the regressions (table 33).

Data used

Table 33. Symbols and sources of data used

Variable	Symbol for growth rate (% change)	Symbol for levels
Employment in the informal sector	Levels are differenced to obtain the growth rates	INFNY
Informal sector earnings		
Formal sector earnings (business wage rate is used as a proxy)	WBPP	An index is computed using WBPP
Previous employment in the informal sector	Lagged values for employment in the informal sector	Lagged values for employment in the informal sector
Labour productivity	LBQP	LPTQI

7.1 Growth-based regression

Table 34. Correlation matrix of the growth based regression

	DINFNY	WBPP	DINFNY1	LBQP
DINFNY	1			
WBPP	0.15	1		
DINFNY1	0.575	0.11	1	
LBQP	–0.19	0.46	–0.29	1

The correlation matrix (table 34) shows that the variables are not highly correlated. The only strong correlation is between current and previous levels of employment in the informal sector. In our estimation, we attempted to drop one of these variables and examine the results that were generated. The model estimated using all the variables identified above is shown in annex 4.

From the results, only the lagged value of earnings in the informal sector is significant. R- squared is only 34.3%, which could suggest that additional variables are needed in the model. The model did not pass any diagnostic test except the ARCH test. The stability test shows shocks to the model. Therefore, an attempt is made to incorporate a dummy for 1991, and other adjustments. The preferred model is reported below:

$$DINFNY = 0.002119509412WBPP + 0.6290613197DINFNY1 +$$
$$(0.961) \quad (5.149)$$
$$0.0002123747831LBQP + 0.571754318D91 + 0.002437481033$$
$$(0.0557) \quad (6.2002) \quad (0.073)$$

$R^2 = 0.791$; D-W = 1.7196; F = 16.98*; BG= 0.95(0.41); n = 23
$RBAR^2 = 0.74$; RESET = 44.5(0.00); J-B = 8.358(0.02); ARCH 0.63(0.44)
Figures in parentheses are t-values, and *shows significance at 1% level.

Inclusion of a dummy for 1991 yields results that are not statistically different from previous ones. From this equation we note the increase in the size of R- squared. The model yields the expected signs for the explanatory variables. The model generates a positive relationship among formal sector earnings, previous levels of employment in the informal sector, labour productivity, and level of employment in the informal sector. The dummy for 1991 also is found to be statistically significant.

7.2 Level-based regression

Table 33. Description of variables used in the level-based regression

Symbol	Description: variables in levels
INFNY	Employment in the informal sector
INFNY1	Lagged value for INFFY
LPTQI	Labour productivity
WBPI	Formal sector earnings

Table 34. Correlation matrix for of level-based regression

	INFNY	INFNY1	LPTQI	WBPI
INFNY	1			
INFNY1	0.99	1		
LPTQI	0.17	0.11	1	
WBPI	0.98	0.97	0.22	1

From the correlation matrix (table 36), employment in the informal sector is highly correlated to its lag, and also to formal sector earnings.

Table 36. Summary of unit root test*

Test	INFNY	INFNY1	LPTQI	WBPI
ADF	2.79886	3.0881	−2.5309	2.555
PP	5.0121	5.0697	−1.4054	3.385

* The 1% and 5% levels of significance for both tests are −3.75 and −2.997, respectively.

These results show that all the variables are not integrated of order zero and are non-stationary but follow an $I(1)$ process. Therefore, we proceed by conducting the cointegration test. This will enable us to establish whether or not the variables have a long-run relationship.

Table 38. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
$r = 0$	0.56	32.92	24.31	29.75
$r \leq 1$	0.42	18.33	12.53	16.31
$r \leq 2$	0.38	8.63	3.84	6.51

From the test above, we have full rank. Notwithstanding this result, we estimated an equation with all the identified variables (disregarding the level of correlation) and generated the results reported in annex 4.2. All variables from the model had the expected signs. However, only formal sector earnings and the lagged value of total employment in the informal sector were found to be significant. The model failed the normality test. A stability test shows that the model becomes unstable around 1991. Thus, a dummy for this period is introduced, and the preferred model is reported below:

$$INFNY = \underset{(0.4259)}{0.00071462LPTQI} + \underset{(1.1539)}{0.0003496WBPI} + \underset{(18.2136)}{1.107939INFNY1} +$$

$$\underset{(11.0167)}{0.528264D91} - \underset{(-0.6957)}{0.1159186876}$$

$R^2 = 0.9984$; D-W = 1.164; BG = 1.68016 (0.2244); RESET = 48.3816 (0.00); n = 20; $RBAR^2 = 0.9979$; F = 2312.919 (0.00); J-B = 1.5157 (0.4687); ARCH = 0.3244 (0.576)

Figures in parentheses are t-values.

8 Private Consumption

8.1 The theoretical model and its empirical variant: private consumption

The theoretical underpinning of the private consumption equation of KTMM is a hybrid of a simplified (two-period) intertemporal substitutions model and a Friedmanist permanent income hypothesis model. The model first defines an intertemporal utility function that is optimized subject to a two-period budget constraint. Using Lagrangian multipliers, the empirical variant of capturing the notion of consumption smoothing, where basically $C_t = C_{t-1}$, is derived (see Huizinga et al. 2001).

Imposing the assumption of permanent income—including initial wealth—in addition to further algebraic manipulation will result in the final equation that is reproduced below:

$$c_1 = \left(1 + \frac{g}{2+r}\right) y_1^d \; + \; \left(\frac{1+r}{2+r}\right) wealth_0$$

Where c_1 = real consumption in period 1, y_1^d = real disposable income in period 1, r = real interest rate, and g = the rate at which income is assumed to grow.

Dropping the wealth variable—because of lack of reliable data—results in the following estimable variant:

$$C_t = \beta_0 + \beta_1 r_t + \beta_2 Y_1^d{}_t + \varepsilon_t \qquad (8)$$

8.2 Previous studies and their specification: private consumption

In MEPM, a simple Keynesian consumption model for Kenya was estimated where disposable income was the major variable explaining private consumption. Though the data covered the period 1972–1993, the regression estimation was based on the period 1975–1993. The following equations were the preferred models in MEPM:

$$\ln NPRC = \underset{(-3.49)}{-2.5031} + \underset{(72.01)}{1.0047}\ln NPRDY + \underset{(2.96)}{0.6055}\ln WSHARE + \underset{(3.11)}{0.0580}\ln INFL - \underset{(-2.57)}{0.0867}D85$$

$R^2 = 0.9985$; $RBAR^2 = 0.9981$; D-W =1.84

$$\ln NPRC = \underset{(-2.61)}{-2.3501} + \underset{(33.65)}{0.9969}\ln NPRDY + \underset{(2.43)}{0.5736}\ln WSHARE + \underset{(2.84)}{0.0571}\ln INFL + \underset{(0.30)}{0.1581}\ln INTR - \underset{(-2.5)}{0.0883}D85$$

$R^2 = 0.9986$; $RBAR^2 = 0.9980$; D-W = 1.82

$$\ln NPRC = \underset{(-2.51)}{-3.7118} + \underset{(13.91)}{0.9427}\ln NPRDY + \underset{(2.75)}{0.79682}\ln WSHARE + \underset{(2.12)}{0.0474}\ln INFL + \underset{(0.93)}{0.1416}\ln RLMBL - \underset{(-1.51)}{0.0635}D85$$

$R^2 = 0.9986$; $RBAR^2 = 0.9981$; D-W =1.8

Figures in parentheses are t-values.

Where NPRC = nominal private consumption, NPRDY = nominal disposable income, WSHARE = share of wages to domestic product, INFL = inflation, INTR = minimum interest rate on savings, RLMBL = real money balance.

In MELT 3, consumption is similarly specified as a function of disposable income, which is derived from a two-year moving average of GDP at factor cost. M2, deflated by consumer price index, also is included as a regressor in the model. The authors found coefficients of 0.21 and 0.18 for disposable income and real M2, respectively. Both, including the constant value of 274.13, are found to be statistically significant.

8.3 Estimation for KTMM: private consumption

Data used

- *Disposable income (DGDP)* is generated by subtracting corporate profit taxes and direct taxes from GDP at market price, then adding transfers.
- *Real disposable income (DGDPREAL)* is generated as a ratio of disposable income (DGDP) to GDP deflator (GDPDEF). The result is multiplied by 100.
- *Private consumption (CHQY)* is generated as a ratio of private consumption at market price to the consumer price index multiplied by 100.
- *Wealth.* Property income could have been used, but because the number of observations was limited, this variable was dropped from the estimation.

Table 39. Definition of variables

Variable	Symbol for level	Symbol for growth rates
Private consumption	CHQY	CHQP
Disposable income	DGDPREAL	DGDPRP — derived as (DGDPREAL-DGDPREAL(-1))/100
Interest rate	INTREAL	INTREAL

8.3.1 Growth-based regression

The correlation matrix (table 40) shows that correlation of the explanatory variables is not high enough to cause multicollinearity problems.

Table 40. Correlation matrix for growth base model

	CHQP	DGDPRP	INTREAL
CHQP	1		
DGDPRP	0.49	1	
INTREAL	0.2	–0.25	1

The estimated growth-based equation is reported below:

$$CHQP = \underset{(4.8)^*}{1.910231DGDPRP} + \underset{(2.8)^*}{0.233200INTREAL} - \underset{(-3.09)^*}{10.766184D8185} +$$

$$\underset{(2.3)^{**}}{13.6556D92} - \underset{(-1.4)}{2.7769}$$

$R^2 = 0.648$; D-W = 2.13; J-B = 1.3 (0.51); BG = 1.33 (0.26)
$RBAR^2 = 0.574$; F = 8.7*; RESET = 0.7 (0.4); LM = 1.4(0.24); n = 24
Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

The estimation results are theoretically plausible and stable. Both disposable income and interest rate are significant. The dummy variables used to capture various shocks also are significant. The estimation can improve if more relevant explanatory variables are included in the specification.

8.3.2 Level-based regression

The correlation matrix (table 41) shows that the explanatory variables are correlated; hence, we expect a problem of multicollinearity. Dropping any variable may not be advisable, since there are only two explanatory variables. Moreover, multicollinearity is not a problem in a dynamic model. Adding more observations or disaggregating the existing ones may solve the multicollinearity problem.

Table 41. Correlation matrix of level-based equation

	LCHQY	LDGDPREAL	INTREAL
LCHQY	1		
LDGDPREAL	0.94	1	
INTREAL	0.57	0.59	1

Table 42. Summary of unit root tests*

Test	LCHQY	LDGDPREAL	INTREAL
ADF	–0.258	–0.82	–2.53
PP	–0.567	–1.668	–3.759

* 1 and 5% levels of significance for both tests are –3.73 and –2.99, respectively

Table 43. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
r = 0	0.842	60.23	29.68	35.65
r ≤ 1	0.58	19.38	15.41	20.04
r ≤ 2	0.01	0.21	3.76	6.65

The time series property above shows that the series follow an I(1) process, and there is one cointegrating vector. Hence, the theoretically specified equation is estimated and reported as the long-run model:

LCHQY = 1.15966LDGDPREAL – 0.00000001INTREAL + 0.203989D74 +
(13)* (-0.03) (2.5)**

0.332638D75 + 1.2954
(4.15)* (1.88)***

R^2 = 0.942; D-W = 0.88; J-B = 0.06 (0.96); BG = 8.9 (0.01); F = 78*; RESET = 10.8 (0.00); LM = 0.73 (0.4); n = 24

Figures in parentheses are t-values, and *, ** and *** show significance at 1, 5 and 10%, respectively.

The estimation is sensitive to the 1972–1976 data. It shows that disposable income is a significant determinant of private consumption. Interest rate is insignificant both in magnitude and by test of significance. However, it was significant in the growth-based (short-run) equation. The estimation could not pass the RESET test. This may be attributed to the fact that important explanatory variables may have been excluded from the model, as explained by the significant constant term. This may suggest that there is need for more work on the wealth variable.

9 Exports

9.1 The theoretical model and its empirical variant: exports

The theory for determining export volume is developed in two stages.[12] First, exports are defined as foreign demand for Kenyan goods using a CES utility function of the trading partners. This has resulted in an export equation with quantity of world trade and the world trade price in domestic currency and price of exports as an argument. Second, an ad hoc supply factor (lagged value of the share of investment in GDP) is incorporated. The export equation in percentage terms, together with its estimable variant, is given below:[13]

$$\hat{x} = \alpha\hat{w}t - \sigma(\hat{p}_x - \hat{p}_{wt}(\$) - \hat{e}) + \phi\left(\frac{i}{y}\right)_{-1}$$

$$\dot{X} = \beta_0 + \beta_1\dot{W}_t + \beta_2\dot{P}_{xt} + \beta_3\dot{P}_{wxt} + \beta_3 e_t + \beta_4\left(\frac{i}{y}\right) + e_t \qquad (9)$$

Where X = exports, P_x = export price, P_{wx} = world price of tradables, e = nominal exchange rate, i/y = investment to GDP ratio, and W_t = world trade.

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[12] At this stage of the model's development we are using an aggregate export function.

[13] With respect to prices, some studies (see Bond 1983, 1987) use the export price of the country concerned (say Kenya) relative to average commodity price of the commodity in question. This can be accommodated within the existing model. However, the implication for the exchange rate equation is that we need to use domestic price in that model and, thus, have RER = ePx/Pd.

9.2 Previous studies and their specification: exports

In the theoretical specification of KTMM, it can readily be seen that a rise in export prices (P_x) has a negative effect on exports; but a rise in nominal exchange rate (deprecation of the Kenya shilling) has a positive effect. This is sensible from the demand side. Moreover, a rise in the world price of tradables (P_{wx}) has a positive effect on Kenya's exports (through the substitution effect). In the model, supply proxied by investment to GDP ratio (i/y) has a positive effect, demonstrating the small-country assumption.[14]

Most export supply models for developing countries do not start from a CES structure as such. In some models the quantity of exports of commodity *k* demanded from region R is the function of the ratio of export price of commodity *k* from region R to the average price of commodity *k* in the international market and real income in importing countries. Supply is specified as a function of current and lagged ratios of export price of commodity *k* to the domestic price level in the producing countries in region R multiplied by the exchange rate of currencies of the producing countries (i.e. USD per unit of local currency), an index of productive capacity in the region, supply shocks (SS_R) and a trend t. Normalizing the supply equation for the price of exports in region R yields an equation that, together with the demand equation, may be estimated simultaneously to obtain estimates of the structural parameters.

[14] One concern here is that if Kenya were a small country, demand may not matter since its exports would always be below its potential demand. Hence, supply could simply be a function of relative prices (real exchange rate) and supply factors (such as i/y). In fact, this is the approach widely employed in most commodity models for developing countries. This implies changing the theoretical specification given for KTMM (see Huizinga et al. 2001). An interesting development for the future is to combine a global commodity model, say for coffee, with an export supply function of Kenya, which is specified using the small-country assumption (see Alemayehu, forthcoming, for such a set-up).

Some models specify production in the short run as a function of prices, supply shocks and potential production. Other models emphasize the importance of commodity stock holding. Thus, supply, demand and price equations incorporate stockholding identities. Such models assume that stocks are held willingly by commodity stockholders, who are seen as having forward-looking rational (or model consistent) expectations. Both demand and supply are assumed to be functions of current and lagged series of past prices. The price equation is an inverted stock demand function. It is a function of expected price and change in (or level of) stocks (H), together with other exogenous variables, particularly interest rate. With this structure, estimation can be done for each, predominantly by OLS and in some cases by IV (instrumental variables).

This preliminary observation shows how primary commodities are modelled in the literature. They indicate that an alternative to the KTMM specification noted above would be to use a simultaneous, equation-based block for Kenya's major exports.

A micro-level study for Kenya's manufacturing sector finds that efficiency and firm size are significant determinants of exports. The study also notes that employment and capital have positive and negative effects on exports, respectively. This may suggest the probability of exports to increase with labour intensity. Ownership and size also are important in deciding whether to become an exporter, but they do not explain the proportion of output to export. While it is found that more efficient firms tend to become exporters, their efficiency level is found not to affect their export share. Common determinants (of the decision to export and the export share) are firm age, which has a negative effect, and labour, which has a positive effect (see Graner and Isaksson 1998).

9.3 Estimation for KTMM: exports

The export equation is specified using two versions. In the first version, using a CES utility function of the trading partners as described in the theoretical section, KTMM specifies exports as foreign demand for Kenyan goods. We attempted to estimate this function but did not find theoretically plausible results. The second version specifies exports from the supply side using the small-country assumption. Income of the trading partners, relative prices, and other supply-inducing factors are also used. In both specifications the effect of the supply side is incorporated by adding in the model investments as a ratio of GDP. The estimation results based on the second version of the export equation are the ones reported in this section.

Data used

The variables used in the estimation equation are summarized in table 44.

Table 44. Definition of variables

Variable name	Symbol (in levels)	Symbol (growth rates—% change)
Export volume	BVY	BQP
Real exchange rate	RER$I/RERXI (derived)	RER$P/RERXP (% change)
Income of trading partners	YTRADI (derived)	YTRADP (% change)
Investment as a ratio of GDP	IGDPRY	IGDPRYP (% change)

- *Real exchange rate* was computed using two versions; one based on export price and the other on world price:

  RER$I = (KSDRY*WPI$)/CHPI
  RERXI = (20*BPI)/CHPI

  Where KSDRY = nominal exchange rate; WPI$ = world trade price index generated from WDPP (% change in world trade price in US dollars); BPI = export price index; CHPI = consumer price index

- *Income of the trading partners (YTRADI)* was computed as a weighted average of GDP volume index for the United Kingdom, Germany and the Netherlands, the key destinations for Kenya's exports in the North. Ideally, Tanzania and Uganda should have been included as trading partners, but this was omitted for lack of sufficient data points. Consequently, YTRADI was computed as

YTRADI = 0.48 UKgdpi + 0.32Ggdpi +0.21Ngdpi

Where 0.48, 0.32 and 0.21 represent weights of Kenya's exports to the United Kingdom, Germany and the Netherlands, respectively, computed for the period 1994–1997 from 1999's *Economic Survey Data on Exports* (see GoK 1999: 102). UKgdpi, Ggdpi and Ngdpi refer to the GDP volume index (from IFS) for the United Kingdom, Germany and the Netherlands, respectively.

9.3.1 Growth-based estimation[15]

The (supply-based) equation is of the following form:

$$BQP = \beta_0 + \beta_1 RER\$P + \beta_2 YTRADP + \beta_3 IGDPRYP + e_n$$

Where $\beta_1 > 0$ $\beta_2 > 0$ $\beta_3 > 0$

Table 45. Correlation matrix of the growth-based variables

	BQP	IGDPRYP	RER$P	YTRADP
BQP	1			
IGDPRYP	0.27	1		
RER$P	0.39	–0.029	1	
YTRADP	–0.09	0.05	–0.27	1

Table 45 shows that the explanatory variables are not highly correlated and, therefore, the degree of multicollinearity is too low to be of concern. The estimated (growth-based) export equation is given below:

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[15] In both growth-based and level-based equations, real exchange rate based on the world price (RER$I) was preferred to real exchange rate based on export price (RERXI), because of better results in terms of significance and theoretical expectations.

$$BQP = 0.1554827182IGDPRYP + 0.6165932877RER\$P + 0.8136546102YTRADP + 41.13939365D95 - 1.469032475$$

(1.77)*** (4.87)* (0.68) (5.20)* (-0.44)

$R^2 = 0.7$; D-W = 2.24; J-B = 0.26 (0.88) ; BG = 0.92 (0.63); n = 22

RBAR^2 = 0.63; LM = 1.38 (0.24); RESET = 1.17 (0.28)

Figures in parentheses are t-values, and *and *** show significance at 1 and 10%, respectively.

A dummy for 1995 was included to capture the outliers/shocks in the series. This yielded fairly better results, as reported above. The coefficient signs of the other explanatory variables are positive, as expected. However, income of trading partners (YTRADP) is not significant. This could be due to the fact that this variable captures only part of the demand for Kenya's exports. A sizeable amount of Kenya's exports are consumed by the neighbouring countries (Tanzania and Uganda), whose income data was not available. The results show that real exchange rate (% change) is the most significant variable that influences growth of exports.

The model above is re-estimated using another dummy for 1994 (the results are shown in annex 6.1). Although the results of the two equations are fairly similar, the model reported here is superior in terms of diagnostic tests, particularly J-B and RESET. In general, the estimated results of the growth-based model show that the percentage change in real exchange rate is the key determinant of Kenya's export growth in the short run. This is plausible, given the small-country assumption. The other determinant of export growth is the share of investment in GDP, though this is not as significant as real exchange rate in terms of magnitude.

8.3.2 Level-based estimation

Table 46 shows the correlation matrix of the level-based variables. The results of unit root and cointegration tests are given in tables 47 and 48, respectively.

Table 46. Correlation matrix of the level-based variables

	LBVY	LIGDPRY	LRERSI	LYTRADI
LBVY	1			
LIGDPRY	–0.41	1		
LRERSI	0.84	–0.5	1	
LYTRADI	0.98	–0.37	0.83	1

The correlation matrix for the level-based variables shows that real exchange rate (LRERSI) is highly correlated with income of trading partners (LYTRADI). At the estimation level, we took this into consideration by including an equation in which one of the correlated variables was omitted from the regression.

Table 47. Unit root tests (on levels)

Test/variable	LBVY	LIGDPRY	LRERSI	LYTRADI	Critical value	
					1%	5%
ADF	0.36	–2.25	–1.38	0.58	–3.74	–2.99
PP	–0.44	–3 29	–1.27	0.35	–3.72	–2.99

Table 48. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
r = 0	0.8	59.85	47.21	54.46
r ≤ 1	0.51	25.83	29.68	35.65
r ≤ 2	0.36	10.92	15.41	20.04
r ≤ 3	0.07	01.5	3.76	6 65

The unit root tests show that all the variables are non-stationary (in levels) and follow an I(1) process. However, the Johansen cointegration test indicates that there is one cointegrating vector at the 1% level of significance. Following these results, the export (level-based) equation, including all the explanatory variables (above) and a dummy, is estimated and reported below:

LBVY = -0.02597178608LIGDPRY + 5.79097546LYTRADI +
(-0.19) (28.06)*

0.4239486049LRERSI – 0.3907130956D7987T92 – 15.97413026
(2.89)* (-9.56)* (-24.1)*

$R^2 = 0.99$; D-W = 1.99; J-B = 0.06 (0.97); BG = 0.78 (0.68); n=23
LM = 0.04 (0.84); RESET = 0.19 (0.66)
Figures in parentheses are t-values, and * shows significance at 1%.

After estimating several equations with different dummies, the model above was finally preferred on the basis of its better diagnostic and specification tests. The estimation results appear theoretically plausible and are statistically significant. A dummy defined for the 1979/1987–1992 periods also is significant. Apart from real exchange rate coefficient, the estimated results of the level-based equation differ from those of the growth-based equation. Income of the trading partners (YTRADI) is insignificant in the growth-based equation but highly significant in the level-based one. On the other hand, gross investment as a ratio of GDP (IGDRPY) is statistically significant and positive in the former but insignificant and negative in the latter. Lagged IGDPRY is found to be insignificant. Thus, the most significant and consistent variable is real exchange rate. Attempts to exclude LYTRADI on the basis that it is highly correlated with LRERSI create problems with diagnostic and specification tests, specifically the RESET and the J-B tests (this estimation, which also has a dummy for the 1995–1997 period, is reported in annex 6.2).

10 Money Demand and Domestic Nominal Interest Rate

10.1 The theoretical model and its empirical variant: money and interest rate

The monetary block in the model is not very detailed. At this stage M2 is the money supply aggregate considered in the model. This is a much narrower definition compared with other aggregates published by the Central Bank of Kenya, such as M3, M3X and the new M3XT. Since a key assumption of the model is a floating exchange rate, money supply is available as an exogenous monetary policy instrument. Therefore, the key variables in KTMM are money demand and nominal interest rate. The demand function for M2 in KTMM is quite conventional. The driving variables are price level, real GDP and nominal interest rates on bonds. Thus, the equation for money demand as given in the theory paper is simply

$$\hat{M}2^d = \alpha\hat{Y} - \beta\Delta i + \gamma\dot{p}$$

Where Y = real GDP, i = nominal interest rates, and p = price level.

The estimable counterpart of this is given as

$$\dot{M}2_t^d = \beta_0 + \beta_1\dot{Y}_t + \beta_2\dot{i} + \beta_3\dot{p} + \varepsilon_t \qquad \beta_1 > 0; \beta_2 < 0; \beta_3 > 0 \quad \text{(10a)}$$

The stability of this function will need to be tested, as an unstable function may not augur well with a macro model. The interest rate moves to clear the money market; thus, nominal interest rates are a function of money supply, real demand and prices. That is,

$$\Delta i = \frac{1}{\beta}\left(\alpha\hat{Y} + \gamma\hat{p} - \hat{M}2^s\right)$$

The estimable version of this equation would be

$$\Delta i = \beta_0 + \beta_1\dot{Y}_t + \beta_2\dot{p}_t + \beta_3\dot{M}2_t^s + \varepsilon_t \quad \beta_1 < 0; \beta_2 > 0; \beta_3 < 0 \quad \text{(10b)}$$

Note here that in equilibrium, demand for money equation is sufficient to show the dynamics of interest rate, as interest rate is an inverted form of money demand.

10.2 Previous studies and their specification: money and interest rate

A fairly standard form of demand for money equation is modelled in MEPM, where interest rates and income are the main determinants. The quantity of money used in the model is the broad total comprising currency outside banks and all bank deposits, but excluding government deposits and deposits of non-resident banks. These are the quantities outstanding at the end of December of each year. Two alternative interest rates were used in MEPM: the minimum rate of interest on saving deposits and the long-term lending rate of commercial banks. Using a sample period of 1975–1993, the estimated equation results for MEPM are

$$\begin{aligned} \ln RLBL = &-4.8176 + 1.5304\ln RGPFC_{-1} - 0.20957\ln INTR_{-1} + 0.1588D77T79 - \\ &(-4.48) \qquad (9.66) \qquad (-2.13) \qquad (3.35) \\ &0.08171D89 + 0.2408D93 \\ &(-1.33) \qquad (3.34) \end{aligned}$$

$R^2 = 0.9731$; $RBAR^2 = 0.9627$; D-W = 1.85; sample = 1975–1993

$$\begin{aligned} \ln RLBL = &-3.7718 + 1.4437\ln RGPFC_{-1} - 0.3126\ln CBLR_{-1} + 0.1684D77T79 - \\ &(-8.38) \qquad (18.56) \qquad (-3.96) \qquad (8.21) \\ &0.1087D85 - 0.0944D8889 + 0.3137D9293 \\ &(-3.86) \qquad (-3.87) \qquad (7.12) \end{aligned}$$

$R^2 = 0.9944$; $RBAR^2 = 0.9917$; D-W = 2.11; sample = 1975–1993

Where RLBL is real money balances defined as (M2/DFGDP)*100 (where DFGDP is the deflator for total GDP at factor prices), RGPFC is real GDP at factor cost, INTR is minimum rate on savings deposits, CBLR is long-term loan rate of commercial banks, D77T79 takes account of the impact of the coffee boom on the stock of real balances, D89 is the effect on real balances of the collapse in coffee prices in 1989, and D9293 takes account of the sharp acceleration of money supply during 1992 and 1993 on account of loose administration of statutory rates and ratios.

From the results above, elasticity of demand for real balances with respect to lagged income is considerably higher than one. This might suggest that real money balances are a luxury commodity. It also means that income velocity of money falls with rise in income, which is expected in a developing country as a result of progressive monetization. Elasticity of demand for money with respect to interest rate is also significant and has the expected sign. The second equation is the one that was used for projection in MEPM. However, no justification was offered for the lag structure used in the income variable, as, in theory, money demand for a given period is mainly determined by that period's income.

There are a number of models for Kenya for demand for money. One study that covered the 1967–1988 period (using quarterly data) is that of Killick and Mwega (1990). After an excellent survey of monetary policy issues in Kenya, Killick and Mwega estimated a demand for money equation (for M1, M2 and M3) mainly to examine the stability of the velocity of money that they found unstable (hence ineffectiveness of monetary policy) from statistical inspection. Their money demand model had as explanatory variables the usual variables (real income, price and interest rate) and a lagged money term (which was their addition).[16] They found inflation rate, lagged value of money and rate of interest as statistically significant, while the income variable was weak. They noted, however, that their result differed from that of Kanga (1985) and Ndele (1990), who found a strong impact for the income variable. An interesting finding of Killick and Mwega's (1990: 29) model was that the use of M1, M2 and M3 seemed to have virtually no effect, except on the constant term.

Adams (1992) estimated a dynamic demand for money equation for five types of definition of money (M0 to M3 and a modified M3). In addition to the standard explanatory variables, he used indicators of currency substitution and an inflation rate. Use of the latter indicator assumes that demand for money is homogenous of degree one with respect to price. Adams found a long-run relationship between the

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[16] Although Killick and Mwega (1990) did not define the use of the symbol '^' and that it is not clear that they used levels or growth rates, we have assumed here that they used growth rates because the title of their table reads 'short-run money demand function'.

variables, and he modelled demand for money in an error correction form. His results reveal that the long-run demand model has income elasticity equal to unity in the M0 (currency) model. However, this coefficient declines as the definition of money broadens. Adams attributed this change to a shift from transactions to portfolio considerations. He also noted that his results were significantly lower than of other studies. Killick and Mwega's results were quite variable across the different definitions of money. The difference is attributed to inclusion of inflation effect (Adams 1992: 250). He also found the currency substitution effect to be quite weak; the adjustment coefficients were around 20%, and one of the cointegrating vectors (that relates to inflation and interest rate) did not significantly enter in the model. The major conclusion of Adams' work is that the error correction models capture the dynamics of money demand in Kenya.

Another recent money demand function is that of Ndung'u and Ngugi (1999). As noted under the section on inflation, the money demand model of Ndung'u and Ngugi was motivated by the objective of explaining movement of prices. Domestic price, real income and interest rate (on treasury bills) were set as explaining demand for money (M2). This equation was inverted for price, and the rest of their study focused on estimating inflation. In the course of that, however, they found a cointegrating vector for demand for money and estimated that long-run equation. The result shows that the money demand equation exhibits long-run elasticity coefficients of 1.72, 1.422 and –0.32 for price, income and interest rate, respectively.

10.3 Estimation for KTMM: money and interest rate

Data used

- *M2 (M2VN) and M3 (M3VN).* The growth rates (M2VNP) and (M3VNP) are generated.
- *Interest rate.* The Treasury-bill rate, given as TBRY, is used.

- *Price* is the consumer price and is given as CHPP (for growth) and CHPI (for the level-based estimation).

- *Real GDP* is given as GDPQ (for growth-based equation) and GDPREAL (for level-based equation).

10.3.1 Growth-based regression

The correlation matrix in table 49 shows that the explanatory variables are not highly correlated, except perhaps for CHPP and GDPQP. The two variables are examined together and separately at the estimation stage.

Table 49. Correlation matrix: money demand equation

	M2VNP	GDPQP	CHPP	TBRY
M2VNP	1			
GDPQP	−0.17	1		
CHPP	−0.06	−0.52	1	
TBRY	0.16	−0.38	0.09	1

The growth-based estimation for the money demand equation is found to be difficult. The model renders not only statistically insignificant coefficients but also theoretically implausible signs for all the explanatory variables. Thus, this result is not reported here. Various experiments with dummies and with different sample points could not improve the performance. This effectively forced us to focus on level-based estimation, which is reported below. Perhaps estimation of the short-run model requires high-frequency data, as can be observed from previous studies.

10.3.2 Level-based regression

Table 50. Summary of unit root tests*

Test	LM2VN	LGDREAL	LCHPI	TBRY
ADF	0.7	−1.22	0.003	−1.93
PP	0.51	−1.44	−0.27	−2.51

* The 1 and 5% levels of significance for both tests are −3.73 and −2.99, respectively.

Table 51. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
r = 0	0.84	71.3	39.89	45.58
r ≤ 1	0.6	29.36	24.31	29.75
r ≤ 2	0.2	8.37	12.53	16.31
r ≤ 3	0.13	3.16	3.84	6.51

Tables 50 and 51 show the time series properties of the components of the money demand equation. The first table shows that the series are non-stationary in levels, and the two tests (ADF and PP) give consistent results. All are found to follow an I(1) process. The cointegration test suggests one and maybe two cointegrating vectors at 1 and 5% levels of significance, respectively. This can be further examined at a later stage using λ-max statistics and other techniques. What is most important at this stage is the existence of a long-run relationship. On the basis of this finding, the following long-run equation is estimated:

$$LM2VN = -8.43851 \underset{(-4.85)^*}{} + 1.937293LGDPREAL \underset{(7.14)^*}{} - 0.005718\,TBRY \underset{(-2.94)^*}{} + 0.58514LCHPI \underset{(5.35)}{}$$

$$+ 0.609142\,D9397 \underset{(8.5)^*}{}$$

$R^2 = 0.99$; D-W = 1.77; J-B = 0.57 (0.75); n = 24

$RBAR^2 = 0.99$; F = 1896.96*; RESET = 0.19(0.67); LM = 0.097 (0.34)

Figures in parentheses are t-values, and * shows significance at 1%.

The model above is quite good in terms of diagnostic tests and predictive values. All signs, if not magnitudes, accord with a priori theoretical expectations.

10.4 Interest rate

In KTMM, nominal interest rate is assumed to be an inverted money demand function. Thus, nominal interest rate can be derived from the money demand equation estimated above.

After examining the simulation properties of the above money demand and (the inverted) interest equations, we estimated the interest rate equation directly by setting it as a dependent variable. This resulted in the following equation used in the model:

LTBRY = -38.6 – 2.472655LM2VN + 4.967148LGDPREAL +
(-2.5)* (-2.98)* (2.65)*

2.203590LCHPI +1.16 D9397
(2.53) (2.4)*

$R^2 = 0.82$; D-W = 1.56; J-B = 0.16 (0.92); n = 24
$RBAR^2 = 0.79$; F = 21.19*; RESET = 0.13 (0.72); LM = 0.56 (0.51)
Figures in parentheses are t-values, and * shows significance at 1%.

11 Exchange Rate

11.1 The theoretical model and its empirical variant: exchange rate

Exchange rate in KIPPRA's model is specified following Dornbusch (1976). Implicitly assuming nearly perfect capital mobility, uncovered interest rate parity (UIP) is the underling theory behind the specification. Moreover, the specification allows for capturing the possibility of overshooting. This is given in the following equation:[17]

$$\hat{e} = \alpha(\Delta i^f - \Delta i) + \beta(\Delta i^f - \Delta i) - \beta(\Delta i^f - \Delta i)_{-1} + (\hat{p}_d - \hat{p}_f)_{-1}$$

Where $\hat{e}$ is the nominal exchange rate, i and i^f are domestic and foreign interest rates, respectively, and P_d and P_f are domestic and foreign prices, respectively.

[17] An alternative specification is that of Ndung'u and Ngugi (1999: 465–477), where the estimable exchange rate equation can be specified as a function of domestic and foreign prices as well as domestic and foreign real interest rate differential.

Its estimable variant can be specified as:

$$\dot{e}_t = \beta_0 + \beta_1 \dot{i}_{d_t} + \beta_1 \dot{i}_{d_{t-1}} + \beta_2 \dot{p}_{d_{t-1}} + \varepsilon_{t-1} \quad (11)$$

Where i_d and p_d show the interest rate and price differential, respectively, and the coefficient β_1 is the sum of α and β in the theoretical equation.

Given the estimated coefficient of β_1, α of the structural equation parameter can readily be derived.[18] This effectively implies that the adjustment to a steady state is made in one period, and the overshooting is captured by the interest rate differential of the preceding period. It is also possible to estimate the model using domestic and foreign prices separately (instead of their difference) as done by Ndung'u and Ngugi (1999: 476).

11.2 Previous studies and their specification: exchange rate

In MELT 3, real exchange rate is formulated by specifying it as a function of lagged real exchange rate and ratio of foreign exchange reserves to total imports. This estimation is done using an arbitrary scale variable and instrumental variables. The authors found statistically significant results for only the lagged value of real exchange rate, which has a coefficient of 0.34. In MEPM, the other applied Kenyan model, exchange rate is not specified at all.

The conclusion that emerges from existing applied macro models for Kenya is that they are specified on an ad hoc basis with no plausible theory. Not surprisingly, the empirical result is very weak. As we have noted above, however, Ndung'u and Ngugi (1999) developed an exchange rate model (in the context of their inflation study), and their model can be employed usefully. Moreover, recently, there has been an in-depth study of KTMM (see Were et al. 2001).

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[18] Another option is to estimate the UIP portion separately.

11.3 Estimation for KTTM: exchange rate

Data used

Table 52. Definition of basic variables

Variable	Symbol for growth rate (% change)	Symbol for levels
Exchange rate	ERPP	KSDRY
Domestic price level	CHPP	CHPI
World trade prices	WPP	WPI: 1982 was used as the base year and then an index is generated from the growth rates (WPP)
Domestic Interest rates (91-day Treasury-bill rate)	Levels were differenced to obtain this value	TBRY
Foreign interest rates (US short-term interest rates)	Levels were differenced to obtain this value	ILUSRY

11.3.1 Growth-based estimation

Table 53. Description of variables used in growth-based regression

Symbol	Description: growth rates (% change)
ERPP	Nominal exchange rate
GPD	Price differential ($P^d - P^f$)
GID	Interest rate differential ($r^d - r^f$)

Table 54. Correlation matrix for the growth-based regression

	ERPP	GPD	GID
ERPP	1		
GPD	0.09	1	
GID	0.1	−0.68	1

The result from the correlation matrix shows that price and interest rate differentials are highly correlated. Having obtained this information, the estimation was done based on the flexible-price monetary model. The first equation estimated included lagged values of both interest rate and price differentials as additional explanatory variables. However, the results indicated that both (lagged) values were not statistically significant. The insignificant lags were then omitted from the estimated equation. It was also noted that there was a shock around 1992. This shock was later modelled by including a dummy (D92), and the following results were generated:

$$ERPP = 0.1743305611GPD + 0.2841175471GID + 71.00660996D92 + 7.871367319$$
$$(0.8879) \quad (1.0718) \quad (6.744) \quad (3.418)$$

$R^2 = 0.744$; D-W =0.85; F = 16.5*; ARCH 0.050 (0.82); n = 21

$RBAR^2 = 0.7$; BG = 4.27 (0.03);J-B = 1.33(0.51); RESET 2.56(0.13)

Figures in parentheses are t-values, and * shows significance at 1%.

The growth-based estimation produced statistically insignificant results. However, the variables had the expected signs. The implication could be to run the model using high-frequency data, which is done in Were et al. (2001).

11.3.2 Level-based regression

Table 55. Description of variables used in level-based regression

Symbol	Description: variables in levels (log-form)
LKSDRY	Exchange rate
LPD	Price differential
LID1	Interest rate differential
LPD1	Price differential lagged once
LID11	Interest rate differential lagged once

Table 56. Correlation matrix of the level-based regression

	LKSDRY	LPD	LID1	LPD1	LID11
LKSDRY	1				
LPD	−0.88	1			
LID1	0.92	−0.89	1		
LPD1	−0.93	0.86	−0.8	1	
LID11	0.89	−0.82	0.83	−0.9	1

The correlation matrix shows that all the variables are highly correlated. This might point to the possibility of a multicollinearity problem in our estimation.

Table 57. Summary of unit root tests

Test	LKSDRY	LPD	LID1
ADF	–0.0206	–1.279	–1.4914
PP	–0.0738	–1.2624	–1.18399

1 and 5% level of significance for the tests are –3.73 and –2.99, respectively

Both tests (ADF and PP) show that the variables are non-stationary in levels and follow an I(1) process. This implies that there is need to test for possible cointegration among these variables. The results shown in table 11.3(6) indicate the existence of a cointegrating vector.

Table 58. Johansen cointegration test procedure

Null hypothesis	Eigenvalues	λ_{trace}	5% level	1% level
$r = 0$	0.76	38.6	29.68	35.65
$r \leq 1$	0.45	11.45	15.41	20.04
$r \leq 2$	0.01	0.14	3.76	6.65

The estimated model included lagged values for both price and interest rate differentials as additional explanatory variables. At the estimation stage, the period 1993–1997 seems to show a regime shift (this is when a major liberalization effort was made in the sector). We attempted to model this by introducing a dummy. After much exploration, we arrived at the following preferred model:

$$LKSDRY = \underset{(1.918)^{**}}{0.5496522514LPD} + \underset{(6.436)^{*}}{0.4296642766LID1} - \underset{(-5.996)^{*}}{1.715837561LPD1} +$$

$$\underset{(0.221)}{0.01624214716LID11} + \underset{(4.257)^{*}}{0.5405732447D96} + \underset{(5.969)^{*}}{1.534824243}$$

$R^2 = 0.9799$; D-W = 1.791; F = 146.1*; J-B = 0.67 (0.72); ARCH = 0.17 (0.69); n = 21; $RBAR^2 = 0.97$; BG = 0.098 (0.91); RESET = 0.02(0.9)

Figures in parentheses are t-values, and * and ** show significance at 1 and 5% level, respectively.

The estimated model passes all the diagnostic tests. The model yields the expected positive signs for price and interest rate differentials. Interest rate differential, when lagged one period, has an expected sign. Although not significant, the lagged value of interest rate differential is retained in this model. Graphed actual and predicted values of the exchange rate showed that the model fairly traced the actual values, while the CUSUM test revealed that the estimated coefficients were fairly stable.

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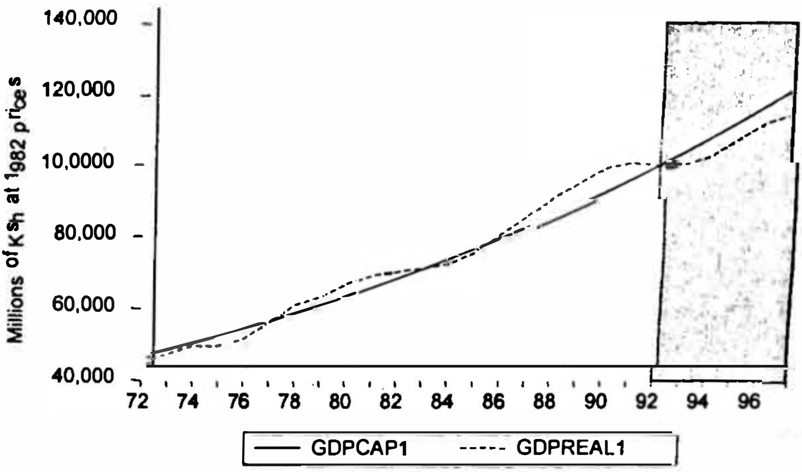
Annex 1. Capacity Utilization

Real GDP (GDP at 1982 market prices) is regressed over time (logGDPreal1 = a+bTREND). This is assumed to depict the potential (capacity) output (GDPCAP1). The rate of capacity utilization is defined as actual to potential ratio. The latter is denoted by QRATE1.



Actual and potential output

Annex 2. Export Prices

Annex 2.1. Growth-based estimation

The estimated export price (growth-based) equation using all the explanatory variables is given below:

BPP = 0.5959490849LUQP + 0.5519865457MPP + 0.5050212677INTREAL +
(2.36)** (3.53)* (3.13)*

5.260520529QRATE1 + 0.3627830127PCOMPXP – 8.685469392)
(0.11) (3.64)* (-0.17)

R^2 = 0.73; D-W = 1.9; F = 9.55*; J-B = 6.88 (0.03); BG = 0.2 (0.9)
RBAR²=0.65; ARCH (LM) = 0.21 (0.89); RESET = 0.003 (0.95); n = 24
Figures in parentheses are t-values, and * and * show significance at 1 and 5%, respectively.

The coefficients of all the explanatory variables are positive, as expected, and statistically significant, except QRATE1. Although this is a good model on the basis of magnitude, signs and significance of the coefficients, the Jarque-Bera (J-B) normality test indicates that the distribution of the error term is not normal. Normality of the error term is necessary for efficiency and consistency of the OLS estimates to hold. In addition, an analysis of the residuals reveals a shock/outlier in the series, which necessitates inclusion of a dummy for 1995. The estimation result (including the dummy) is given below:

BPP = -30.78170877D95 + 0.3333205038INTREAL + 0.6840448071LUQP +
(-4.36)* (2.76)* (3.81)*

0.2592778234PCOMPXP – 42.30808947QRATE1 + 0.4787052879MPP +
(3.48)* (-1.20) (4.07)*

40.93194865
(1.13)

= 0.87; D-W = 1.83; J-B = 1.08 (0.58); BG = 0.38 (0.83); n = 24

$RBAR^2 = 0.82$; F = 19.08*; ARCH (LM) = 0716 (0.7); RESET = 0.32 (0.57)
Figures in parentheses are t-values, and * shows significance at 1%.

The dummy is negatively signed and very significant. All other variables are statistically significant as before, except capacity utilization, which now is statistically insignificant. Specification and diagnostic tests, including the normality test, are fairly good.

Annex 2.2. Level-based estimation (without dummy)

LBPI = 0.1649944738LPCOMPX + 0.1851621321LMPI + 0.7835473484LLUQI +

(2.21)** (1.88)*** (7.78)*

0.00604086759INTREAL – 0.2745035029LQRATE1 – 0.608968583

(3.69)* (-0.57) (-1.59)

$R^2 = 0.993$; D-W = 1.76; F = 488.87*; J-B = 3.52 (0.17); n = 24
$RBAR^2 = 0.991$; BG = 0.2 (0.91); LM = 0.61 (0.73); RESET = 0.6 (0.44)
Figures in parentheses are t-values, and *, ** and *** show significance at 1, 5 and 10%, respectively.

Annex 2.3. Estimation excluding import price (highly correlated with LLUQI)

LBPI = 0.1718295358LPCOMPX + 0.007652732833INTREAL +

(2.39)* (4.96)**

0.009188745327LQRATE1 + 0.975373381LLUQI – 0.1956568955D96 –

(0.02) (37.96)* (-2.23)*

0.6993582903

(-1.91)***

$R^2 = 0.993$; D-W = 2.02; F = 521.2*; J-B = 0.62 (0.73); BG = 0.44 (0.86); n = 24
$RBAR^2 = 0.991$; ARCH LM = 0.23 (0.89); RESET = 2.04 (0.15)
Figures in parentheses are t-values, and *, ** and *** show significance at 1, 5 and 10%.

Annex 3. Wage-related Generation of Data

Annex 3.1. Wage rate

1. Wage rate (WBPP)

There are two wage rates in KTMM: the business sector (WBPP) and government workers' (WGPP) wage rates. For estimating the wage determination equation, the wage rate for the business (modern) sector is used. This is generated from available data using the following formula:

$((WBVY/WBVY_1)/(WBNY/WBNY_1)-1)*100$

Where WBVY is the level of wages in millions of shillings for the business sector, and WBNY is the volume of wage employment in millions in the business sector.

Data exploration shows that in 1994 there was a sharp increase of 55% in the wage rate: this is the year when a legislative change gave more leeway to employers and employees to negotiate collective bargaining agreements. Wage in 1994 appeared to be an extreme outlier, and it has been neutralized in the estimated equation with a dummy for that year.

2. Consumer price (CHPP)

As mentioned above, consumer price was chosen for the price variable, given that it is a function of value-added price. Choosing one of the two price[19] variables in the wage equation avoids the multicollinearity problem at the estimation stage. The consumer price

[19] As mentioned in the estimation part of this equation, both prices were included in the equation, since through the correlation matrix it was realized that there was no serious correlation between the two variables. However, the value-added price was found to be highly insignificant in the wage equation and, thus, the judgment to have only consumer price in the wage determination equation is justified.

variable is the inflation rate of private consumption (CHPP) generated by dividing current private consumption by constant private consumption in the SNA figures.

It is important to recognize that CHPP differs from the CPI inflation reported by the Central Bank of Kenya. The latter is based on urban CPI and, therefore, is likely to be different from the CHPP generated from SNA.

3. Value-added price (VAPP)

On further reflection it was decided that it was important to explore the significance of value-added price in the wage equation. As a result, value-added price, which is the same as the GDP deflator, was generated using GDP data. For the growth-based equation, value-added price was generated as follows: first, the GDP deflator (VAPI) was given as

VAPI = (GDP Nominal (GDPVY)/GDP Real (GDPREAL))*100

Where GDPVY is nominal GDP in market prices, and GDPREAL is GDP at constant 1982 market prices.

The growth rate of value-added price was then computed in the normal way using the following formula:

$$VAPP = ((VAPI_t - VAPI_{t-1}) / VAPI_{t-1}) * 100$$

4. Labour productivity (LBQP)

This is defined as the units of output produced by a unit of labour (LBQP). Labour productivity was very erratic over the sample period. In 1993 it fell to –18.1. This was followed by a tremendous improvement, reaching 9.9 in 1994. It has had a declining performance ever since. The period 1993–1994 was found to be mimicking the wage rate, further strengthening the case for introducing a dummy for 1994.

5. Direct taxes and social security contributions paid by employees, s_l

The other variable needed in the wage determination equation is direct taxes and social security contributions by employees. Pension contribution by employees does not form a significant amount of payroll deductions in Kenya. As a result, only direct taxes are used in generating this variable. Tax rate is generated as the proportion of total direct taxes to total wage earnings.

6. Social security contributions, pension benefits and other benefits paid by the firm, s_f

This variable, which in theory is part of the equation, has not yet been included in the wage equation estimated. A relevant proxy needs to be determined for social security contributions and other labour-related costs, other than wages paid by the firm.

7. Unemployment rate, ***ur***

The current database for the model makes it difficult to determine the unemployment rate in the economy. This is mainly due to the unavailability of data on employment for the traditional sector. A crude approximation method, which will need to be refined, has been employed to generate the unemployment rate for the wage equation. A shifting proportion of the labour force was used to determine employment in the traditional sector. The following proportions were used: 1972–1980 (70%), as indicated in the Wanjigi report on unemployment; 1981–1990 (68.4%), as computed from information in the Ndegwa report on employment; 1991–1995 (51.3%), as calculated from the unemployment rate of 21.3% observed in the Welfare Monitoring Survey II; and 1996–1998 (40%). The implicit assumption then is that the proportion of the workforce not employed in smallholder agriculture and in pastoralism forms the unemployment population in both urban and rural areas. Thus, total employment in the economy was calculated to be the sum of wage employment in business (WBNY), self-employment (SENY), wage employment in the government (WGNY), informal sector employment (INFNY) and employment in the traditional sector

(TRANY). Unemployment was then the difference between total labour force (LFORNY) and total employment. Hence, unemployment rate (URPP) is this residual (in percentage terms) as a proportion of the total labour force.

Annex 3.2. Wage employment

1. Wage employment

The model has two forms of wage employment: wage employment in the business sector (WBNY) and wage employment in the government (WGNY). Other forms of employment exist, but these are not considered in the wage employment model. These are self-employment (SENY), informal sector employment (INFNY) and traditional sector employment (TRANY). For purposes of projecting wage employment as discussed in the theory paper, wage employment in the business sector is used. Wage employment in the government is projected separately. Therefore, the variable used is wage employment in the business sector (WBNY). The percentage change variable is given as WBNP. The change in wage employment over time has been oscillating but with some level of stability, except in 1993 and 1994. In 1993, wage employment grew by more than 20% over the previous year. However, this growth was short lived, as there was a fall of 13% the following year. This possibly can be explained by the employment that accompanied the 1992 general elections. These two years (1993–1994) may be captured by using a dummy in order to establish whether the period was a significant shock in the labour market.

2. Real wage

As established in the optimal derivation of wage employment demand from the CES function, one of the explanatory variables is real wage. This is computed from business sector wage deflated by value-added price. Value-added price, as indicated previously, is similar to the GDP deflator. Therefore, real wage is given as

WBR = WBPI/VAP

Where dividing WBVY by WBNY and forming an index with 1982 = 100 derives WBPI. Percentage (growth) change in real wage is given as

$$WBRP = ((WBR - WBR_{-1})/WBR_{-1})*100$$

Two distinct regime shifts are evident from graphing the percentage change in real business wage; these are 1975–1978 and 1993–1995. The latter coincides with a similar shift that occurred in wage employment itself.

1. Real GDP

Real GDP is the other variable in the wage employment equation. This is given as the variable GDPQP in growth rate terms. It is generated as the sum of growth rates of the individual components of GDP, that is, consumption, investment, government consumption and trade balance.

2. Profit rate

A performance indicator in the form of a profit rate was introduced in the wage employment equation in a rather ad hoc manner as a determinant of the level of employment. Dividing disposable profit income (ZDISVY) by the value of invested capital (CAPVZ) gave the profit rate (PINC) used in the regression equation.

$$PINC = ZDISVY/CAPVZ$$

Therefore, profit income growth rate (PINCP) was computed as follows:

$$PINCP = ((PINC-PINC_{-1})/PINC_{-1})*100$$

Annex 4. Employment in the Informal Sector

Annex 4.1. Employment in the informal sector (growth-based estimation)

DINFNY = 0.00243908273WBPP + 0.5464412472DINFNY1 –
(0.642) (2.611)**

0.002926025038LBQP + 0.03302849367
(-0.449) (0.581)

R^2 = 0.343; D-W = 2.365; F = 3.309*; RESET = 8.111 (0.0106); n = 23
RBAR^2 = 0.24; BG = 3.0784 (0.07228); J-B = 64.52 (0.000); ARCH = 0.3913 (0.5386)
Figures in parentheses are t-values, and * and ** show significance at 1 and 5%, respectively.

Annex 4.2. Employment in the informal sector (level-based estimation)

INFNY = 0.004835760964LPTQI + 0.001366089457WBPI +
(1.0128) (1.62154)***

0.8914777111INFNY1 – 0.5864204916
(5.3042)* (-1.24715)

R^2 = 0.985; D-W = 2.2; RESET = 0.0045 (0.947); ARCH = 0.1028 (0.7524); n = 20
RBAR^2 = 0.982; BG = 0.2052 (0.8169); J-B = 42.924 (0.000); F = 357.08*
Figures in parentheses are t-values, and * and *** show significance at 1 and 10%, respectively.

Annex 5. Investment Equation (Full Sample)

5.1. Growth-based parsimonious equation (full sample)

IBQP = 2.785603413 + 2.770993057GDPQP – 0.5756612432IPP +
(0.32) (3.12)* (-1.15)

133.3928879QRATE
(1.48)

R^2 = 0.38; D-W =2.34; J-B =0.97 (0.61); BG = 0.85 (0.37); n = 24
RBAR^2 = 0.27; F = 20.7*; RESET = 0.56 (0.46); LM = 0.16 (0.85)

Annex 6. Export Supply Equations

Annex 6.1. Growth-based export supply model (with dummy for 1994)

BQP = 0.1682974397IGDPRYP + 0.5746927381RERSP + 1.225682119YTRADP
(2.18)** (5.14)* (1.16)

+39.17158423D95 – 16.15913144D94 – 1.607488796
(5.62)* (-2.49)** (-0.55)

R^2 = 0.87; D-W = 2.29; J-B = 1.05 (0.59); BG = 2.9 (0.23); LM = 0.16 (0.69); n = 22; RESET = 2.29 (0.13)

Annex 6.2. Level-based export supply model (with dummy for 1995–1997), excluding LYTADI

LBVY = 2.877298937LRER$I – 0.2289315146LIGDPRY + 1.196190895D95T97

(11.3)* (-0.57) (7.69)*

+ 2.542099347

(3.95)*

R^2 = 0.94; D-W = 1.67; J-B = 0.2 (0.9); BG = 0.24 (0.89); n = 22
LM = 0.17 (0.68); RESET = 4.3 (0.04)

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