DAIRY IMPORTS INTO THE DEVELOPING WORLD: A CROSS-COUNTRY CO-INTEGRATION ANALYSIS

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1. Introduction

Most developing countries import significant quantities of milk and dairy products to fill the gap between their domestic production and consumption. The total quantity of milk available for consumption and other uses in the developing world was 228 million Metric Tonnes (MT) in 1998. Total domestic production was 208 million MT while net imports accounted for the remaining 20 million MT (FAO, 1998). For the developing world as a whole, net imports accounted for 9% to 12% of the total quantity of milk available for consumption and other uses. This proportion varies significantly, as for example, from 8% for Brazil to over 90% for the Philippines (Table 1). As net importers, changes in imports of dairy products into developing countries will be sensitive to developments in world markets for dairy products, including such factors as product prices, currency exchange rates, consumer purchasing power as well as developments within the domestic dairy sub-sectors. Changes in dairy imports are therefore a reasonable indicator of changes in domestic dairy production and consumption because imports will increase as the consumption-production gap widens.

This paper provides a quantitative analysis of factors that determine dairy imports into the developing world. Previous studies (e.g. von Massow, 1984; 1985) often fail to explore the statistical properties of the individual variables used and do not examine the validity of their econometric model. Not only is the power of the statistical tests reduced, but also the confidence one can place in the empirical results of these studies. In this study I employ a cross-country co-integration analytical method to evaluate the effects of factors that determine dairy imports into ten countries within five regions of the developing world. The countries are: East Asia - China; South and Southeast Asia - Malaysia, Philippines and Thailand; Latin America - Brazil and Mexico; sub-Saharan Africa - Nigeria; West Asia and North Africa - Algeria, Egypt and Saudi Arabia. These ten countries accounted for 44% and 60% of the total net imports of dairy products into the developing world in 1985 and 1998 respectively. Involving several countries across different regions of the world in the analysis not only will improve understanding of the reasons why dairy imports are high for certain countries, but also have important implications for developments in the respective domestic dairy industries.

2. Imports of dairy products into the developing world

The developing world as a whole recorded net imports of approximately 20 million MT of dairy products in 1998. Total net imports increased by about 7% between 1985 and 1998. Regional imports show different growth patterns during this time period. Latin America, the second largest net importing region of dairy products in 1985 became the first importing region with 5.6 million MT in 1998. Together, Brazil and Mexico accounted for 68% of the total net imports in this region (Table 2). Net imports increased in both countries with Brazil experiencing a six-fold increase between 1985 and 1998.

In South East Asia, 80% of the increase in total milk availability was due to increased net imports, which was consistent with rapid income growth and generally less favorable conditions for dairy cattle in that region. Net imports increased by more than half between 1985 and 1998 due mainly to a doubling of net imports in the Philippines and Thailand which together with Malaysia, accounted for 55% of the region's total net imports. Net imports of dairy products also increased in East Asia where China was the dominant importer with over 86% of the regional imports. Like in India and South Asia, sub-Saharan Africa (SSA) and West Asia and North Africa (WANA) experienced a decrease in net imports. This was in part due to dramatic reductions in 'consessional' imports offered by developed countries. In spite of the overall decline in net imports in SSA, Nigeria, which accounted for over half of sub-Saharan Africa's net imports of dairy products in 1998, experienced a two-fold increase in net imports between 1985 and 1998. In WANA, Algeria, Egypt and Saudi Arabia that accounted for about 45% of the region's total net imports, all experienced a decline in net imports of dairy products between 1985 and 1998.

Although regional total net imports of dairy products exhibit different growth patterns, for the developing world as a whole, the total quantity of net imports increased only slightly between 1985 and 1998. This however, was because the decline in consessional imports experienced in SSA and WANA was offset by an increase of similar magnitude in 'commercial' imports, particularly by the countries of Southeast Asia (Tambi et al., 2001).

Regional growth patterns in net imports per capita closely mimic those of total net imports. Except for SSA and WANA where net imports per capita declined, the rest of the regions experienced an increase in net imports per capita. For the developing world as a whole however, net imports per capita decreased from 5.3 kg in 1985 to 4.7 kg in 1998. In South and Southeast Asia where Malaysia imported about 55 kg of dairy products per person in 1998, imports averaged 5.7 kg per person (Table 2). In the WANA region where Algeria and Saudi Arabia imported 69 kg and 83 kg of dairy products respectively in 1985, net imports per capita dropped by more than half in 1998.

The different patterns of growth observed in dairy imports into the developing countries appears to be a reflection of the short- and long-run effects of domestic policies adopted by the countries. For example, most countries often have adopted the policy to cut down on imports and increase domestic production through the importation of high yielding exotic breeds or through the use of artificial insemination. However, poor adaptability of the exotic animals to the local environments, coupled with poor dairy management practices means that most of these measures have only short-term benefits. Lack of sustainability has made it difficult to capture long-term benefits, making it possible for most countries to revert to dairy imports. Proper understanding of the dynamics behind dairy imports requires therefore, that both the short-run and long-run effects be taken into account.

2.1. Determinants of dairy imports into developing countries

An important factor that has encouraged rapid growth in dairy imports into developing countries has been growth in per capita income. There has been an overall increase in per capita income within the last three decades in all the countries considered in this study except Algeria and Nigeria. In Brazil, China, Malaysia, Mexico, the Philippines and Thailand, net imports of dairy products increased in accordance with increasing per capita income. In Algeria, net imports increased with per capita income until 1993 but thereafter, net imports declined as per capita income dropped. Despite the overall increase in per capita income in Egypt, net imports declined by about half between 1988 and 1998. The relationship between per capita income and net imports of dairy products in Nigeria could not be established because that country experienced significant fluctuations in net imports despite a two-fold decrease in per capita income from 1982 to 1998. This implies that factors other than income might have played a major role.

Changes in the prices of dairy products also have had far reaching effects on dairy imports into the developing world. Time series data on domestic dairy products prices is grossly inadequate for all the countries considered in this study. However, since all of these countries are net importers of dairy products, changes in domestic dairy prices would have little or no effect on the additional demand for imports as all domestic stocks are cleared regardless of the domestic price level. Import prices therefore, are a more important determinant of quantities imported than would be domestic prices. Measured in US$/kg milk equivalent, the average import price of dairy products in each of the ten countries did not vary significantly from one country to another except for Saudi Arabia (Figure 1). However, there were significant price changes within certain countries. In China, Malaysia and Thailand, net imports of dairy products increased despite the overall increase in import prices from 1970 to 1998. Net imports in Brazil and Mexico increased in accordance with import prices from 1970 to 1980. However, the increase in import prices experienced from 1981 to 1984 was accompanied by a reduction in net imports. Saudi Arabia experienced an increase in import prices from 1970 to 1984. Thereafter, import prices dropped until 1988. Net imports into that country rose steadily until 1992, after which it decreased until 1995. Overall, import prices in Nigeria showed an increasing trend, peaking in 1979 at US$0.48/kg.

Developments in the domestic dairy industry appeared to also have influenced the pattern of imports of dairy products in to the developing world. For example, the developing world as a whole experienced an increase in total cow's milk[1] production of 48 million MT between 1985 and 1998 (Table 3). This rapid increase of 4.4% per year appeared to have slowed down the rate of increase (0.5% per year) in net milk imports. The increase in domestic milk production was due to an increase in the productivity of individual cows (38%), an expansion of the size of the cattle herd (29%) and an increase in the proportion of cows milked (19%). The rest of the increase was attributed to the combined (interaction) effects of the above factors (Tambi et al., 2001). Although total cow's milk production increased in all regions of the developing world, not all regions experienced an increase in productivity. In East Asia, China experienced a 6% decline in productivity and in South and Southeast Asia, Malaysia experienced a 9% decline in productivity of cow's milk. In sub-Saharan Africa, productivity stagnated at 239 liters per cow per year between 1985 and 1998.

For the countries considered in this study, the relationship between domestic milk production and net imports of dairy products is not unique. In China, both net imports of dairy products and domestic milk production more than doubled, suggesting a very high demand for milk in that country. In Malaysia, the Philippines and Thailand where domestic production of milk has been insignificant because of unfavorable conditions for dairy cattle, net imports increased, again, suggesting increased demand for dairy products in those countries. Even though as major dairy producing countries in Latin America, Brazil and Mexico experienced an increase in domestic milk production, both countries exhibit different growth rates of net imports of dairy products. In Brazil net imports rose by over 600% while in Mexico net imports rose by only 9%. Growth in net imports of dairy products in Nigeria between 1985 and 1998 outpaced domestic milk production by about ten times, meaning that the country relied heavily on imports rather than on domestic milk production. In the WANA region, the relationship between domestic milk production and net imports in Algeria, Egypt and Saudi Arabia was quite different from that of the countries in the other regions. In all three countries, the increase in domestic milk production led to a general reduction in net imports. This is a reflection of the adoption of policies that aim at cutting down on

[1] Cow's milk production accounts for 63% of the total milk produced in the developing world followed by buffalo's milk (29%), while the remaining 8% comes from other animal species.

imports by increasing domestic production through the introduction of high yielding dairy production technologies.

3. Methods

To evaluate the impact of factors influencing dairy imports into the developing world, the annual quantity of net imports in country i (NI_{it}), calculated and expressed as milk equivalents was modelled as a function of the import price of dairy products (IP_t), consumer income as measured by the real per capita gross domestic product (INC_t) and the level of domestic production of dairy products (DP_t). The model specification is given in Equation (1).

$$ln NI_t = \beta_{0t} + \beta_1 ln IP_t + \beta_2 ln INC_t + \beta_3 ln DP_t + e_t \qquad (1)$$

A number of studies have employed time series regression analysis similar to equation (1) to measure the impacts of those factors that influence commodity imports (Arize, 1987; Boylan and Cuddy, 1987). Although the studies have helped to derive income and price elasticities of import demand, problems arise in directly applying time series regression analysis to estimate elasticities when variables have strong trends and are non-stationary. As shown by Granger and Newbold (1974), regression models estimated from non-stationary series frequently have high R^2s, highly significant coefficients and low Durbin-Watson statistics. Inferences drawn from such estimates often have been misleading.

Appropriate specification of the time-series in equation (1) requires that each variable be screened through a variety of tests to establish its stationarity property so as to know whether or not to use the variable in its level form or its difference transformation. As shown by Engle and Granger (1987) a stationary variable has a mean, variance and autocorrelation that are constant over time. For a non-stationary variable, the variance may widen indefinitely. Any shock in the system may not return it to a proper mean level. Hypothesis testing using such a non-stationary variable may provide coefficients that are inconsistent.

To determine whether a steady-state (i.e. long-run equilibrium) relationship exists between net imports of dairy products and those variables that influence it, the variables each must be stationary and integrated of the same order. That is, each variable in equation (1) needs to possess similar statistical properties as the other counterpart variables. A variable is integrated of order zero -- $I(0)$ -- when it is stationary in level form. However, a non-stationary time series variable can be made stationary by differencing. If its first difference achieves stationarity, then it is said to be integrated of order one -- $I(1)$. If a second-order differencing achieves stationarity, then the variable is integrated of order two -- $I(2)$ -- and so on.

A relationship that has variables that are stationary and are integrated of the same order is known as a "co-integrated relationship". If the relationship has variables that are integrated of different orders, then it cannot be co-integrated. A co-integrated relationship can be used to determine whether a true long-run equilibrium relationship exists between the dependent variable and the explanatory variable(s). For example, per capita income and dairy imports may exhibit wide variations in the short-run. However, combinations of those variables that influence dairy imports need not also diverge significantly from one another in the long-run. If they do, then the relationship with such non-stationary variables can not be co-integrated and therefore cannot explain the true long-run effects of changes in the explanatory variable(s) on the dependent variable. If conventional regression analysis is applied to such a non-co-integrated relationship, the estimates may become spurious and therefore may not be fit for proper inferences. Stationarity and co-integration therefore are necessary conditions for the derivation of meaningful regression coefficients.

3.1. Stationarity and co-integration testing of dairy import relationships

Stationarity testing for unit roots is a necessary condition for the application of ordinary least-squares (OLS) regression to time-series data (Tambi, 1999; Silvapulle and Jayasuriya, 1994; Johansen, 1988; Engle and Granger, 1987). To test for stationarity and order of integration of the individual variables in equation (1), the augmented Dicky-Fuller (AD-F) test proposed by Engle and Granger (1987) and the

Phillips-Perron (P-P) test are used. These tests are performed by running the following OLS regression on each variable:

$$\Delta ln X_t = \alpha_0 + \delta ln X_{t-1} + \sum_{s=1}^{p} \beta_1 \Delta ln X_{t-s} + e_t \qquad (2)$$

where X_t represents each of the variables in equation (1). The lag length p is chosen to ensure that the residuals e_t generated from equation (2) are serially uncorrelated. The null hypothesis (H_0) being tested is that variable X_t is integrated of order one -- *I*(1) -- as against the alternative hypothesis (H_a) that it is integrated of order zero -- *I*(0). The null hypothesis is rejected if the t-statistic (calculated as the ratio of the coefficient δ to its standard error) is negative and statistically significant when compared to appropriate critical values established for stationarity tests[2]. The stationarity-test results are presented in Table 4.

Following the establishment of the order of integration of each of the variables in equation (1), linear combinations of the explanatory variables that influence the dependent variable are formed to determine whether they were co-integrated or not. If the set of variables involved in the combination are integrated of the same order, then the relationship is co-integrated and therefore, the estimated coefficients can be used to establish the true long-run relationship between dairy imports and their determinants. The AD-F and P-P tests are again used to test for co-integration. Co-integration is tested in two stages. First, a co-integrating regression of the following type is estimated by specifying the COINT Command of the SHAZAM Econometrics Computer Program (White, 1993):

$$X_t = \alpha_0 + \beta Y_t + e_t \qquad (3)$$

where Y_t is a vector of explanatory variables. The command applies OLS regression to the linear combinations of the variables tested for stationarity (i.e. the co-integrating regression) and the residuals are obtained. Using the residuals, the following regression is run:

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[2] These critical values are automatically given in the output data sheet when the SHAZAM program command COINT is used to estimate the stationarity properties of each variable. The COINT command also automatically selects the lag length that is consistent with residuals that are serially uncorrelated. For more on this see Chapter on Diagnostic Tests in White (1993) pp. 169-181.

$$\Delta e_t = -\Psi e_{t-1} + \delta\Delta e_{t-1} + \ldots + \delta\Delta e_{t-s} + \varepsilon_t \qquad (4)$$

where ε_t is the new error structure. After the variables in equation (1) are established to be stationary and their linear combinations determined to be co-integrated, OLS is then applied to equation (1). The results are presented in Table 5. These coefficients describe the long-run relationship that exists between dairy imports and those factors that influence imports.

To determine the statistical appropriateness of the co-integrating regressions, a battery of tests was again applied. These included the autoregressive conditional heteroscedasticity (ARCH) test of Engle (1982), the Breusch-Pagan-Godfrey (B-P-G) test for normality of the residuals (Breusch and Pagan, 1979; Godfrey, 1978), and the Chow (1960) test for structural stability. Results of these diagnostic tests are presented at the bottom of Table 5.

3.2. Error-correction model of dairy imports

As indicated earlier, short-run divergencies observed between dairy imports and their determinants need not also occur in the long-run. To establish whether the short-run effects of changes in the determinants of dairy imports are indeed consistent with the long-run dynamics, an error-correction model (ECM) is necessary. A full error-correction representation would exist if the determinants of dairy imports are stationary and properly co-integrable. The stationarity and co-intergrability conditions demonstrated by the A-DF and P-P tests statistics reported in Tables 4 and 5 make it possible to obtain reliable and consistent values for the steady-state or long-run parameters by estimating the static co-integration relationship. The ECM was necessary because most of the variables included in each of the relationships were stationary in first differences. According to Engle and Granger (1987) ECMs cannot be estimated for relationships that have non-stationary variables or variables that are integrated of different orders. The ECM used to capture the short-run effects that are consistent with the long-run dynamics was specified as:

$$\Delta ln\mathrm{NI}_{it} = \beta_1 + \sum_{s=1}^{n1}\beta_{2i}\Delta ln\mathrm{NI}_{t-i} + \sum_{s=0}^{n2}\beta_{3i}\Delta ln\mathrm{IP}_{t-i} + \sum_{s=0}^{n3}\beta_{4i}\Delta ln\mathrm{INC}_{t-i}$$

$$+ \sum_{s=0}^{n4} \beta_{5i} \Delta ln DP_{t-s} + \lambda EC_{t-1} + \xi_t \quad (4)$$

where the variables NI_t, IP_t, INC_t, and DP_t are as previously defined. The ECM is specified to include ECR_{t-1}, which is derived from the residuals *e* (lagged one period) generated by the equilibrium co-integrating regression as an error-correction variable. The coefficient λ serves as the error-correction coefficient that captures the long-run equilibrium adjustment in dairy imports for given levels of their determinants. It measures the speed with which the relationship moves back to the equilibrium following a shock. $\Delta ln NI_{t-i}$ measures the short-run effects. ξ_t is a random error term assumed to be normally distributed with constant variance.

Given that stationarity was achieved for most of the variables only when the data were differenced once, we then estimated the co-integration regression with undifferenced data and the error-correction equation with first difference data. In the error-correction equation, the lagged value of the residuals from the co-integrating regression was incorporated as a corrective regressor. Before estimating the co-integrating regression equation, further diagnostic tests were carried out to ascertain the statistical adequacy of the model.

3.3. Data

The data used in this study were obtained from two main sources. Annual quantities of dairy products, quantities and value of dairy products imported and exported were downloaded from the FAO Data Base Agristat and net imports were calculated as the difference between quantities imported and quantities exported. Net imports were then expressed as milk equivalents. Import prices were obtained by dividing the value of dairy imports by quantities imported. Per capita income was measured as real per capita gross domestic products obtained from the International Financial Statistics Yearbook (IFS, 1998) published by the International Monetary Fund. Data for all the variables covered the time period from 1970 to 1998.

4. Results

4.1. Diagnostic test results

Diagnostic test results on variables affecting dairy imports are presented in Table 4 as AD-F and P-P statistics for each of the countries considered. Tests of the null hypothesis that each variable is $I(1)$ as against the alternative that it is $I(0)$ reveal that non-stationarity can be rejected for the levels of the following variables: *ln*IP for Algeria, China, Egypt, Malaysia and Nigeria; *ln*NI for Brazil; *ln*INC for Algeria, Malaysia, Philippines and Saudi Arabia; and *ln*DP for Nigeria and the Philippines. For the other variables, the calculated AD-F and P-P statistics are greater than the critical value of -2.57, meaning that they each exhibit a non-stationary series in levels. To allow for the possibility that all the variables are stationary in first-difference form, the null hypothesis that each variable is $I(2)$ as against the alternative that it is $I(1)$ was tested. From the calculated AD-F and P-P statistics in the second part of Table 4 we are able to reject the null hypothesis of non-stationarity for all the variables. Note however, that upon differencing, domestic dairy production (*ln*DP) in Egypt and Nigeria retain a single unit root, implying that this variable remained non-stationary. We conclude from these diagnostics that each of the other variables has a single unit root that cancels out when differenced once. Thus, the variables are integrated processes of order one.

Having achieved stationarity in first-difference form, tests for co-integration of the variables affecting dairy imports were then performed using the data in level form. The results are presented in Table 5 as the long-run coefficients of dairy imports. Before discussing these empirical estimates, it is important to provide some evidence for the statistical appropriateness of the long-run co-integrating regression. The AD-F, P-P and co-integration regression Durbin-Watson (CRDW) statistics obtained from a regression run on the residuals generated from the long-run co-integrating regression are presented at the bottom of Table 5. As can be seen, all the AD-F and P-P statistics are below the critical value of -4.15 for all countries except Nigeria. This supports rejection of the null hypothesis of non-co-integration at $P<0.10$, meaning that the variables that influence dairy imports into nine of the ten countries are co-integrated.

Thus, except for Nigeria, long-run equilibrium relationships exist between dairy imports and its determinants.

Test results to determine whether the relationship between dairy imports and its determinants is structurally stable and possess normally distributed residuals are also presented at the bottom of Table 5. The Jarque and Bera (J-B) (1980) χ^2 distributed statistics with 2 degrees of freedom for normality reveal that all the statistics are below the critical value of 5.99, meaning that the dairy import relationships possess residuals that are normally distributed. This finding is corroborated by the χ^2 distributed autoregressive conditional heteroscedasticity (ARCH) statistics (Engle, 1982) which are all below the critical value of 3.841 except for Nigeria and Saudi Arabia. The Breusch-Pagan-Godfrey (B-P-G) χ^2 test statistics (Breusch and Pagan, 1979; Godfrey, 1978) for autocorrelation with 3 degrees of freedom are not significantly different from zero at the 5 percent level for all countries except Nigeria. The critical value is 7.815. Thus, while we reject the null hypothesis of non-autocorrelation of the residuals for Nigeria, we fail to reject it for the rest of the countries. As evidenced by the F-distributed Chow (1960) test statistics, the dairy import relationships appeared to have been structurally stable for Algeria, Brazil, Malaysia, Mexico, the Philippines and Thailand during the period from 1970 to 1998. For China, Egypt, Nigeria and Saudi Arabia, the dairy import relationship remained structurally unstable during this time period.

Diagnostic test results for the statistical adequacy of the error-correction regression that combines the long-run and short-run dynamics of dairy imports are presented at the bottom of Table 6. As can be seen, the statistical fit of the ECM to the data is satisfactory for all the countries, as indicated by the R^2 adjusted for degrees of freedom and the F value for testing the null hypothesis that all the right-hand side variables as a group, without the intercept, have a zero coefficient. For space consideration, a detailed discussion of the other diagnostic tests results reported at the bottom of Table 6 is not undertaken. However, it is clear that except for Algeria, where the residuals are not normally distributed and are autocorrelated as per the ARCH and B-P-G statistics of 5.954 and 12.410 respectively, the dairy import relationships for all the other countries have normally distributed residuals. The short-run ECM is structurally stable for all the countries except for Algeria, China, and Saudi Arabia.

4.2. Empirical results

Empirical estimates of the short-run ECM are presented in Table 6 while the long-run estimates are presented in Table 5. Note that the ECM coefficients integrate the short-run dynamics in the long-run dairy import demand relationships. The encouraging aspect of the short-run ECM is that the empirical estimates are statistically satisfactory as judged by the adjusted R^2s. Apart from Mexico where the combined effect of income, import price, domestic dairy production and lagged dairy imports explain 66% of the variation in dairy imports, these variables jointly explain from 82% to 99% of the variation in dairy imports in the other nine countries. Given that the regressants are cast in the first difference, the error-correcting variable EC_{t-1} (lagged one period) included in the ECM appears statistically significant ($P<0.05$) and has the hypothesized negative sign for eight of the ten countries. For Mexico and Nigeria, the error-correction term is not statistically significant ($P>0.05$) and is positively signed, meaning that there is no evidence that the short-run dynamics are affected by the long-run dynamics in these two countries. For the other eight countries, there appears to be an equilibrium relationship between dairy imports and its determinants. This is an important finding that supports non-rejection of co-integration among the variables established earlier. Thus, apart from Mexico and Nigeria, the empirical results establish the existence of an underlying stationary relationship between dairy imports and the variables most often considered to be its important determinants in the other countries.

Another important aspect of the results in Tables 5 and 6 is the evidence availed on the role of income in stimulating the demand for dairy imports in all the countries considered. Income is statistically significant for all the countries. However, in Algeria, Brazil and Nigeria, growing income levels appear to be associated with reduced imports of dairy products. The magnitude of the impact of income appears to vary from one country to another. For example, the short-run impact of an increase (e.g. 1%) in money income is to enhance dairy imports by 0.58% in the Philippines and as much as 2.80% in Egypt. In Algeria, rising income levels seem to discourage dairy imports by a very small percentage (-0.07%) compared to -0.52% in Brazil and -0.76% in Nigeria. A comparison of the short-run income coefficients (or elasticities) in Table 6 with the long-run coefficients in Table 5 suggests that the latter are greater in magnitude than the former. This has important implications for adjustments in dairy imports for given changes in money incomes over time. In the long-run for example, an increase in money income would enable consumers in Egypt to adjust upwards their demand for dairy imports by about 3.22% and those in Malaysia by only 0.58%. In Brazil consumers would reduce dairy imports by 0.69% in the long-run, even though income is statistically not significant (P>0,05).

The evidence provided by the results in Tables 5 and 6 on the impact of dairy import prices is mixed for the countries considered. For six of the countries, dairy import prices exhibit the hypothsized negative sign. However, import prices have a significant (P<0.05) but positive influence on dairy imports in both the short-run and long-run only in Brazil, Malaysia, Nigeria, the Philippines and Thailand. In an analysis of dairy imports policy in Mali, von Massow (1985) found that a unit increase in the import price of dairy products significantly increased dairy imports into Mali by 0.91. The short-run impact of an increase in import prices on dairy imports is significantly negative in Brazil and Nigeria but positive in Malaysia, the Philippines and Thailand. In Brazil, the short-run reduction in dairy imports for a given increase in price is large (-1.33%) compared to Nigeria (-0.94%). On the other hand, the short-run increase in dairy imports in Thailand is higher than in the Philippines and Malaysia. Like the income effects, the long-run import price elasticities are greater than the short-run values, again, suggesting greater adjustment of imports to price changes over time. The positive response of dairy imports to import price increases in Malaysia, the Philippines and Thailand could be attributed to the limited domestic production of dairy products in these countries. In 1998 for example, domestic dairy production was estimated at 10, 37 and 372 thousand MT in Malaysia, Thailand and the Philippines respectively. As domestic production remained low, the deficit in domestic demand had to be met from imports, regardless of the import price level.

As the estimates in Tables 5 and 6 indicate, the volume of domestic dairy production is an important determinant of dairy imports. This variable is statistically significant in all the countries except in Algeria, China and Thailand. The hypothesized inverse relationship between domestic stocks of dairy products and imports is true only in Egypt, Mexico and Thailand. A one unit increase in domestic stocks in these countries reduces their demand for dairy imports by more than one unit. Increasing domestic stocks of dairy products in Egypt and Mexico would reduce imports by about four and three fold respectively. On the other hand, in Brazil, Malaysia, Nigeria and Saudi Arabia, imports seem to increase despite an increase in domestic stocks. This is quite pronounced in Brazil and Nigeria where imports increase by about five and two times the rate of increase in domestic stocks. A possible explanation for this is that domestic production in these countries is not only small, but also the rate of increase in production is outpaced by demand, therefore necessitating an increase in imports.

The inclusion of previous levels of dairy imports as a determinant of current levels of imports revealed that apart from Algeria and China, lagged dairy imports do not contribute significantly to current imports in the rest of the countries. When this variable was excluded from the regression for these countries, the level of statistical significance of the other variables was reduced, suggesting that lagged imports do in fact play an important though less significant role in stimulating dairy imports.

4.3. Implications

This study has analyzed the link between imports of dairy products and income, import prices and domestic dairy production in developing countries. Previous studies also have established a strong relationship between dairy imports and these factors (von Massow, 1984; 1985). A comparison of our results with those of these other studies shows a great deal of similarity in the estimates. For example, income and price elasticities derived for Nigeria are quite close to values of 0.66 and -1.88 respectively obtained for imports of animal products including dairy products in Cameroon (Tambi, 1997) where dairy consumption characteristics are similar to those of Nigeria. The high response of dairy imports to income changes observed for Egypt and Mexico is contrary to the values of 0.44 reported by von Massow (1985) for Mali. These differences could have been caused by differences in the data and methodologies used. The long-run import price and income elasticities are greater than the short-run elasticities. Two important implications can be drawn from this. First, the high price elasticities reflect an improvement in the ability of most countries to substitute domestic dairy production for imports as they make progress toward economic development. Secondly, the high income elasticities reflect a greater degree of openness of most of the economies as they liberalize imports. Previous studies by Melo and Vogt (1984); Boylan and Cuddy (1987); and Tambi (1998) attest to the validity of these findings.

The statistical significance of the error-correction terms observed for Brazil, China, Egypt, Malaysia, the Philippines, Saudi Arabia and Thailand imply that short-term changes in dairy imports into these countries are caused by deviations from the long-run equilibrium. The coefficients vary significantly however, from one country to another. In Brazil for example, the value of the coefficient is close to one, implying that deviations from the long-run equilibrium are quickly offset by developments in that country. In the Philippines and Malaysia where the values are quite small, -0.02 and -0.03 respectively, the deviations from long-run equilibrium persist. These shocks on dairy imports could, among other sources, originate from differences in the domestic dairy production and importation policies adopted by these countries.

Investigation of the role of inadequate domestic dairy production in stimulating imports of dairy products shows that the volume of domestic stocks is an important determinant of the volume of imports. The evolution of dairy imports into developing countries therefore, is a reflection of the demand pressure caused by domestic short-falls in dairy production in these countries. Structural problems associated with domestic dairy production in most developing countries often have led to inadequate domestic production, necessitating dependence on dairy imports. Although intensification of dairy production has to a large extent been instrumental in increasing productivity of dairy cattle in some of these countries, total domestic production has remained low and inadequate to meet domestic consumption needs. Saudi Arabia for example, illustrates the effects of large-scale importation of dairy technologies from the developed countries. Yet it produces only 3% of the total milk in the WANA region (Tambi et al., 2001). Even though productivity per milking cow in Saudi Arabia more than quadrupled while total milk production more than doubled between 1985 and

1998, total domestic milk production was still inadequate to meet domestic demand, forcing the country to import significant quantities of dairy products. The fact that in Egypt, Mexico and Thailand an increase in domestic production would result in a greater reduction in imports means that these countries could conserve significant amounts of foreign exchange if measures are adopted to increase domestic dairy production.

The traditional inverse relationship between dairy imports and import prices does not seem to hold for some of the countries considered in this study. In China, Egypt and the Philippines the short-run and long-run response of dairy imports to increasing import prices is positive, suggesting that these countries import significant quantities of dairy products regardless of the price level. In the short-run Malaysia and Thailand also import significant quantities of dairy products regardless of price. This could have been due to increased import speculation in these countries that led to changes in quantities moving in the same direction of price changes. This fact bears greater significance in Nigeria where the continuous depreciation of the Naira led to increased importation (of all goods) in order to avoid higher prices in the future. The "perverse" effects of price changes on dairy imports could also have been due to exchange-rate variability. A decline in the domestic currency (e.g. the Algerian Dina) is reflected in a rise in the domestic import price and thus the relative price of imported dairy products. A depreciation of say 10% of the Algerian Dina, if completely passed through import prices, would cause a reduction of 0.03% in the volume of dairy imports in that country. What these results suggest is that unless efforts are made to increase domestic dairy production in these countries and streamline their exchange-rate policies, dairy imports will continue to drain significant amounts of foreign exchange through higher dairy products prices.

The findings of this study are based on annual national data on dairy imports obtained from the Food and Agriculture Organization Data Base Agristat (WAICENT). The FAO data are the most comprehensive time series available for country and regional comparisons of this type, although they are undoubtedly open to criticism for certain countries where record keeping problems abound. Thus, even though the models remain plausible, one should be cautious about extrapolating the results to all developing countries.

5. Conclusion

Net imports of milk and dairy products account for 9 to 12% of the total quantity available for consumption and other uses in the developing world. Changes in imports thus have implications on developments in the domestic dairy sector. Co-integration and error-correction modelling is used to measure the effects of determinants of milk and dairy imports into ten developing countries. These countries account for 60% of total imports into the developing world. Stationarity and co-integration tests suggest that except in Egypt and Nigeria where domestic dairy production retains a single unit root upon first differencing, all other variables are integrated processes of order one and are co-integrated in the rest of the countries. Additional statistical tests confirm the normality, absence of autocorrelation and structural stability of the dairy import relationships for all countries except Algeria.

Empirical results suggest that apart from Nigeria and Mexico, a long-run equilibrium relationship exists between dairy imports and its determinants in the other countries. Per capita income appears to be an important stimulant of increased imports of dairy products in 70% of the countries examined in the study. However, increasing income levels appear to discourage imports of dairy products in Algeria, Brazil and Nigeria. The role of import prices in influencing dairy imports is mixed for the countries examined. Rising levels of import prices for dairy products are associated with increased imports in Brazil, Malaysia, Nigeria, the Philippines and Thailand; a reflection of inadequate domestic production. Apart from Algeria and China, lagged levels of dairy imports do not seem to influence current levels of imports. Long-run price and income elasticities are greater than the short-run values, implying that the economies of the countries examined in the study are becoming more and more liberal over time.

Overall, the analysis undertaken in this study suggests that stationarity and co-integration testing are not merely warranted when evaluating import demand functions, but is necessary for establishing whether error-correction representation is needed when estimating the short-run dynamics of import demand functions. The statistical appropriateness of the error-correction term for all the countries considered in the study supports co-integration and therefore renders credible the parameter estimates reported herein for dairy imports into the developing world.

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Table 1. Contribution of milk imports to total milk consumption in developing countries, 1985 and 1998.

Region	Total milk consumption, 1985	Net imports of milk		Total milk consumption, 1998	Net imports of milk	
	000 Mt	000 Mt*	% of total consumption	000 Mt	000 Mt	% of total consumption
East Asia:	**7,324**	**1,168**	**16.0**	**15,135**	**2,421**	**16.0**
China	5,839	1,025	17.6	12,334	2,083	17.0
South and South East Asia:	**61,925**	**3,488**	**5.6**	**102,975**	**5,315**	**5.2**
Malaysia	655	606	92.5	1,188	872	73.4
Philippines	626	608	97.1	1,317	1,202	91.3
Thailand	451	371	82.3	1,328	854	64.3
Latin America:	**42,659**	**4,475**	**10.5**	**61,724**	**5,613**	**9.1**
Brazil	13,485	260	2.0	22,298	1,838	8.2
Mexico	8,643	1,788	20.7	10,249	1,951	19.0
Sub-Saharan Africa:	**13,728**	**2,205**	**16.1**	**17,432**	**1,734**	**10.0**
Nigeria	571	284	49.7	1,241	878	70.7
WANA:	**27,629**	**7,292**	**26.4**	**31,030**	**4,806**	**15.5**
Algeria	2,388	1,504	63.0	2,080	834	40.1
Egypt	2,847	781	27.4	3,808	511	13.4
Saudi Arabia	1,369	993	72.5	1,731	861	49.7
Total developing countries	**153,265**	**18,628**	**12.2**	**228,296**	**19,889**	**8.7**

* milk equivalent

Table 2. Net imports of milk into selected developing countries, 1985 and 1998.

Region and country	Net imports of milk (000 MT)*				Per capita net milk imports (kg)	
	1985	% of regional total	1998	% of regional total	1985	1998
East Asia:	**1,168**	**6.2**	**2,421**	**12.2**	**1.7**	**3.2**
China	1,025	87.8	2,083	86.0	0.7	1.1
South & South East Asia:	**3,488**	**18.7**	**5,315**	**26.7**	**4.6**	**5.7**
Thailand	371	10.6	854	16.1	7.7	16.0
Malaysia	606	17.4	872	16.4	40.0	54.5
Philippines	608	17.4	1,202	22.6	11.0	18.0
Latin America:	**4,475**	**24.0**	**5,613**	**28.2**	**12.7**	**18.7**
Brazil	260	5.8	1,838	32.7	6.1	10.5
Mexico	1,788	40.0	1,951	34.8	19.5	20.8
Sub-Saharan Africa:	**2,205**	**11.8**	**1,734**	**8.7**	**3.6**	**3.2**
Nigeria	284	12.9	878	50.6	3.4	8.4
WANA:	**7,292**	**39.1**	**4,806**	**24.2**	**32.1**	**15.5**
Algeria	1,504	20.6	834	17.4	68.7	28.4
Egypt	781	10.7	511	10.6	15.2	8.2
Saudi Arabia	993	13.6	861	17.9	82.7	51.1
Total developing countries	**18,628**	**100.0**	**19,889**	**100.0**	**5.3**	**4.7**

* Milk equivalent

Table 3. Domestic cow's milk production in selected developing countries.

Region and country	Total cow milk production(000 MT) 1985	1998	Yield (kg/cow) 1985	1998
East Asia:	2,619	6,637	1,582	1,482
China	2,619	6,637	1,582	1,482
South & South East Asia:	6,024	9,609	818	1,066
Thailand	21	37	530	481
Malaysia	15	10	1,034	1,041
Philippines	58	372	2,088	2,914
Latin America:	37,380	55,670	1,057	1,171
Brazil	12,545	20,440	733	829
Mexico	8,623	10,229	1,266	1,253
Sub-Saharan Africa:	7,827	11,040	322	345
Nigeria	309	366	239	239
WANA:	14,237	19,858	1,048	1,312
Algeria	536	911	973	1,218
Egypt	865	1,325	949	1,065
Saudi Arabia	152	495	1,475	7,760
Total developing countries	85,588	134,037	757	919

Table 4. Univariate stationarity properties of individual variables.

Country and test	Variable (levels)			
	$ln\mathrm{IN}_{it}$	$ln\mathrm{IP}_{it}$	$ln\mathrm{INC}_{it}$	$ln\mathrm{DP}_{it}$
Algeria:				
AD-F*	-1.972	-1.010	-2.513	-0.903
P-P	-2.194	-2.846	-3.040	-0.889
Brazil:				
AD-F	-1.028	-2.376	-2.301	-1.130
P-P	-2.854	-2.423	-2.181	-2.131
China:				
AD-F	-1.979	-3.187	-0.670	0.166
P-P	-2.059	-3.124	-0.677	0.142
Egypt:				
AD-F	-1.808	-2.783	-0.600	2.341
P-P	-1.805	-2.823	-0.277	3.454
Malaysia:				
AD-F	-1.223	-1.423	-2.737	-0.552
P-P	-1.183	-2.964	-2.460	-0.704
Mexico:				
AD-F	-1.452	-0.375	-2.393	-3.041
P-P	-2.056	-2.026	-2.049	-2.787
Nigeria:				
AD-F	-1.572	-3.626	-1.897	-2.709
P-P	-2.479	-3.844	-1.809	-2.825
Philippines:				
AD-F	-1.476	-0.257	-2.924	-2.589
P-P	-1.316	-2.048	-1.493	-2.592
Saudi Arabia:				
AD-F	-2.248	-4.079	-3.234	-0.977
P-P	-2.189	-2.483	-2.563	-0.117
Thailand:				
AD-F	-0.295	-2.218	-2.352	-0.625
P-P	-0.505	-2.219	-1.421	-0.625

* Critical value at $P<0.10$ for the AD-F (Augmented Dickey-Fuller) and P-P (Phillips-Perron) tests is -2.570

Table 4 cont. Univariate stationarity properties of individual variables.

Country and test	Variable (First differences)			
	$\Delta ln\text{NI}_{it}$	$\Delta ln\text{IP}_{it}$	$\Delta ln\text{INC}_{it}$	$\Delta ln\text{DP}_{it}$
Algeria:				
AD-F*	-3.050	-3.901	-2.947	-2.929
P-P	-7.004	-6.347	-3.023	-6.536
Brazil:				
AD-F	-3.274	-3.459	-3.151	-2.675
P-P	-10.482	-5.217	-3.981	-4.075
China:				
AD-F	-2.572	-2.718	-3.159	-3.410
P-P	-5.257	-4.366	-4.294	-4.568
Egypt:				
AD-F	-3.185	-3.396	-3.129	0.183
P-P	-4.377	-6.426	-5.173	-2.570
Malaysia:				
AD-F	-4.901	-2.687	-2.664	-2.918
P-P	-5.597	-3.845	-3.955	-4.072
Mexico:				
AD-F	-3.350	-4.214	-2.674	-3.528
P-P	-10.137	-5.228	-2.866	-3.770
Nigeria:				
AD-F	-3.097	-3.156	-2.775	-0.051
P-P	-8.052	-6.910	-4.164	-4.332
Philippines:				
AD-F	-3.044	-2.623	-2.946	-3.458
P-P	-7.354	-4.379	-3.303	-5.097
Saudi Arabia:				
AD-F	-3.477	-2.694	-3.183	-3.166
P-P	-3.543	-3.245	-5.343	-3.219
Thailand:				
AD-F	-3.218	-2.926	-3.966	-3.133
P-P	-8.820	-5.553	-6.496	-4.744

* Critical value at P<0.10 for the AD-F (Augmented Dickey-Fuller) and P-P (Phillips-Perron) tests is -2.570.

Table 5. Long-run co-integrating regression estimates of factors influencing dairy imports.

Variable	Country				
	Algeria	Brazil	China	Egypt	Malaysia
Intercept	-0.235	-43.917	0.672	19.485	-1.105
	(-0.309)*	(-3.461)	(0.503)	(3.084)	(-1.167)
$lnIP_t$	0.673	-1.342	0.419	0.785	-0.314
	(2.966)	(-2.504)	(1.609)	(1.565)	(-2.860)
$lnINC_t$	0.807	-0.693	1.099	3.217	0.581
	(7.107)	(-0.619)	(3.460)	(4.231)	(9.515)
$lnDP_t$	-0.139	5.578	-0.0002	-4.266	0.750
	(-1.691)	(2.613)	(-0.0007)	(-3.123)	(3.494)
R^2 Adj.	0.857	0.525	0.906	0.780	0.948
Diagnostics:					
A-DF	-4.152	-4.600	-4.492	-4.982	-5.545
P-P	-5.687	-5.313	-6.598	-5.062	-5.531
CRDW	1.106	1.971	0.856	0.930	1.790
J-B $\chi^2(2)$**	0.452	0.578	1.046	2.793	2.552
B-P-G $\chi^2(3)$	5.474	1.007	5.333	4.374	3.464
ARCH $\chi^2(1)$	0.002	0.123	3.032	0.494	0.130
Chow F(4,21)	1.816	1.849	58.186	15.520	1.204

Critical values are as follows: A-DF and P-P = -4.15; J-B $\chi^2(2)$ = 5.991; B-P-G $\chi^2(3)$ = 7.815; ARCH $\chi^2(1)$ = 3.841; and Chow F(4,21) = 2.840. * t-statistics in parentheses. ** Degrees of freedom in parentheses.

Table 5 cont. Long-run co-integrating regression estimates of factors influencing dairy imports.

Variable	Country				
	Mexico	Nigeria	Philippines	Saudi Arabia	Thailand
Intercept	11.237	-6.376	7.122	-9.894	-0.938
	(1.531)*	(-1.197)	(4.672)	(-2.031)	(-1.108)
$ln\mathrm{IP}_t$	-0.212	-1.004	0.076	-1.158	-0.804
	(-0.600)	(-1.883)	(2.484)	(-1.378)	(-6.640)
$ln\mathrm{INC}_t$	2.099	0.766	0.611	1.110	0.801
	(3.295)	(1.867)	(4.583)	(3.596)	(5.904)
$ln\mathrm{DP}_t$	-2.346	1.914	-1.235	0.904	0.073
	(-1.823)	(2.070)	(-3.431)	(3.009)	(1.126)
R^2 Adj.	0.647	0.100	0.833	0.700	0.948
Diagnostics:					
A-DF	-4.342	-2.793	-4.760	-5.169	-6.174
P-P	-4.935	-2.724	-5.440	-6.558	-7.435
CRDW	1.418	0.756	2.021	0.699	2.474
J-B $\chi^2(2)$**	4.218	0.430	3.864	2.545	0.232
B-P-G $\chi^2(3)$	1.682	8.039	3.394	3.905	4.677
ARCH $\chi^2(1)$	0.293	5.018	1.422	6.293	3.007
Chow F(4,21)	1.816	4.040	0.730	4.521	1.790

Critical values are as follows: A-DF and P-P = -4.15; J-B $\chi^2(2)$ = 5.991; B-P-G $\chi^2(3)$ = 7.815; ARCH $\chi^2(1)$ = 3.841; and Chow F(4,21) = 2.840. * t-statistics in parentheses. ** Degrees of freedom in parentheses.

Table 6. Short-run error-correction regression estimates of factors influencing dairy imports.

Variable	Country				
	Algeria	Brazil	China	Egypt	Malaysia
Intercept	-5.898	-44.393	-0.784	17.042	-0.492
	(-49.790)*	(-48.240)	(-0.679)	(2.863)	(-0.422)
$\Delta lnIP_t$	-0.033	-1.325	0.023	0.434	0.241
	(-1.367)	(-34.900)	(0.091)	(0.883)	(1.797)
$\Delta lnINC_t$	-0.067	-0.521	0.955	2.803	0.581
	(-3.687)	(-9.077)	(3.690)	(3.593)	(9.297)
$\Delta lnDP_t$	-0.007	5.656	0.136	-3.776	0.648
	(-0.978)	(37.100)	(0.603)	(-2.934)	(2.572)
$\Delta lnNI_{t-1}$	0.977	-0.002	0.090	0.137	-0.022
	(6.650)	(-0.231)	(1.913)	(1.038)	(-0.997)
EC_{t-1}	-0.025	-0.904	-0.563	-0.443	-0.032
	(-0.819)	(-7.470)	(-3.443)	(-2.169)	(-2.133)
R^2 Adj.	0.998	0.997	0.940	0.835	0.946
F					
SEE					
Diagnostics:					
J-B $\chi^2(2)$**	0.144	1.650	0.592	3.325	2.839
B-P-G $\chi^2(5)$	12.410	1.579	4.311	8.141	4.951
ARCH $\chi^2(1)$	5.954	0.022	0.771	3.676	0.281
Chow F(6,17)	6.694	0.022	5.412	5.146	2.464

Critical values are as follows: J-B $\chi^2(2) = 5.991$; B-P-G $\chi^2(5) = 11.070$; ARCH $\chi^2(1) = 3.841$; and Chow F(6,17) = 2.70. * t-statistics in parentheses. ** Degrees of freedom in parentheses.

Table 6 cont. Short-run error-correction regression estimates of factors influencing dairy imports.

Variable	Country				
	Mexico	Nigeria	Philippines	Saudi Arabia	Thailand
Intercept	13.674	-5.898	7.243	-7.025	-0.708
	(1.640)*	(-3.996)	(4.373)	(-1.847)	(-0.831)
$\Delta ln IP_t$	-0.461	-0.937	0.061	-0.849	0.768
	(-1.224)	(-4.546)	(2.342)	(-1.323)	(6.296)
$\Delta ln INC_t$	2.050	-0.762	0.609	0.868	0.795
	(3.533)	(-6.896)	(4.334)	(3.402)	(5.956)
$\Delta ln DP_t$	-2.884	1.798	-1.296	0.718	0.084
	(-2.015)	(7.049)	(-3.117)	(3.019)	(1.298)
$\Delta ln NI_{t-1}$	0.102	-0.006	0.010	0.108	-0.029
	(1.138)	(-0.182)	(0.326)	(1.446)	(-1.210)
EC_{t-1}	0.199	0.966	-0.024	-0.548	-0.208
	(0.889)	(0.820)	(-2.109)	(-3.231)	(-1.716)
R^2 Adj.	0.663	0.934	0.819	0.872	0.950
F					
SEE					
Diagnostics:					
J-B $\chi^2(2)$**	18.689	21.500	3.639	3.110	0.942
B-P-G $\chi^2(5)$	3.477	5.756	4.368	5.948	8.791
ARCH $\chi^2(1)$	0.042	0.058	1.304	3.735	3.011
Chow F(6,17)	1.861	1.858	2.254	3.876	1.886

Critical values are as follows: J-B $\chi^2(2) = 5.991$; B-P-G $\chi^2(5) = 11.070$; ARCH $\chi^2(1) = 3.841$; and Chow F(6,17) = 2.70. * t-statistics in parentheses. ** Degrees of freedom in parentheses.