Causal relationship between Meat consumption and economic growth in SEAFO countries: Evidence from panel Granger causality test

Beatrice Simo-Kengne*, Johane Dikgang† and Sunita Prugsamatz Ofstad‡

Abstract

This paper investigates the causal relationship between meat consumption and the growth rate of output in a panel of six member countries of the South East Atlantic Fisheries Organisation for the period 1990 to 2009. We apply a bootstrap panel Granger causality approach on a bivariate VAR comprising of per capita meat consumption and real per capita GDP growth; allowing for both country specific effect and cross-sectional dependence. Our empirical results display a unidirectional causality running from economic growth to meat consumption, which implies that, rising living standards leads to significant increases in meat consumption. Moreover, the absence of reverse causation from meat consumption to economic growth tends to substantiate the detrimental meat effect on health and the environment, which indeed contributes to economic decline.

Keywords**:** Meat consumption, environment, output, panel Granger causality

JEL Classification**:** C32, O44, Q18

* Department of Economics and Econometrics, University of Johannesburg, Johannesburg, South Africa. Email: bdsimo-kengne@uj.ac.za

† Department of Economics and Econometrics, University of Johannesburg, Johannesburg, South Africa. Email: jdikgang@uj.ac.za

‡ Fakultet for samfunnsvitenskap og teknologiledelse , Norwegian University of Science and Technology (NTNU), Dragvoll NO-7491, Trondheim, Norway. Email: sunita.prugsamatz@svt.ntnu.no

1. Introduction

Meat remains an important food group in the diet for many consumers in both developed and developing countries. Nutrient rich food, meat provides valuable amounts of protein, haem iron, zinc, B vitamins, selenium and retinol, with increased bioavailability than found in other dietary sources (Cosgrove et al., 2005; Davey et al., 2003; McAfee et al., 2010). While healthy population is a crucial asset for the development process of a country, Johnson (2009) emphasizes that meat plays an important role in the diets of all age groups by supplying nutrients that enable optimal growth and development in childhood as well as maintenance of health and wellbeing throughout adulthood and well into old age. Therefore, as economy continuously grows and develops, both the industrial and residential needs for meat rise.

The worldwide consumption of meat per capita in 2005 was 41.3 kg, compared to 30kg in 1980. In developed countries, it increased from 76.3kg in 1980 to 82.1kg in 2005. During the same period, developing countries saw a rise from 14.1kg to 30.9kg. Sub-Saharan Africa with the exception of South Africa is the only developing-country region that has seen a modest decline in per capita consumption of meat during this period, from 14.4kg to 13.3kg (FAO, 2009). More importantly, world meat consumption is expected to double by 2050 due to rising income in developing countries (FAO, 2006). Because meat is income elastic, this might increase the volatility of food prices which negatively impacts on food security (Herrmann, 2009).

According to Linseisen et al. (2002), meat can be categorised into red meat (such as beef, lamb, veal and pork), white meat (including fish, chicken, game and turkey) and processed meat (including cured and smoked meats, ham, bacon, sausages, hamburgers, salami and tinned meat)._Unlike white meat, increasing red meat consumption presents issues such as greenhouse gas emissions (Herrmann, 2009), risk of cardiovascular diseases (Fraser, 1999; Kelemen et al., 2005; Kontogiani et al., 2008 amongst others) and risk of cancers (Cross et al., 2007; Wei et al., 2004; Robertson et al., 2005; Kimura et al., 2007; Taylor et al., 2007; Kabat et al., 2009). Furthermore, increasing meat consumption rises meat production which accelerates the rate of deforestation and thereby contributes to soil erosion and desertification. Consequently, meat and particularly red meat consumption is patently unsustainable economically, healthily and environmentally. Henceforth, diversifying the countries' nutrient sources and finding safe and environmental friendly protein supplies have become one of the policy makers' main priorities.

The Food and Agriculture Organisation (2010) indicates that fish and seafood represent the primary source of protein for one billion poorest people on Earth. With seafood, chicken and beef being equivalent in terms of protein supply (Yaktine et al., 2008), seafood is therefore a natural alternative to red meat. Moreover, a growing body of literature documents that consuming seafood may have important benefits for pre- and post-natal cognitive development and helps protect against heart disease and stroke. However, with the current debates on climate change and aquatic ecosystem threats, countries around the world have been facing a dilemma of how to respond to increasing demand in protein which reconciles economic, environmental and health benefits. This is particularly critical for member countries of the South East Atlantic Fisheries Organisation (SEAFO) with primarily aim to safe-guard the long-term conservation and sustainability of all marine resources in the South East Atlantic Ocean, and to protect the environment and marine ecosystems.

Besides EU, SEAFO covers six member countries, namely, Angola, Japan, Namibia, Norway, South Africa and South Korea (or Republic of Korea). Arguably, fish and seafood consumption is likely to be restricted in these countries due to their commitment to protect the oceanic environment. Unsurprisingly, although the consumption of fish is on the rise despite being uneven around the world, there seems to be shifts from seafood to meat eating. According to Gasparatos and Gadda (2009), the two regions in which this trend of "Westernization diet" is most widely manifested are South-East Asia and East Asia. Japan has experienced the most dramatic shifts in the dietary preferences of its citizens from seafood to meat eating. The increasing trend in meat consumption can also be observed from other SEAFAO member countries. The most appealing is South Africa which, in contrast to the Sub-Saharan region, has shown significant increases in per capita consumption levels in 2005, with an average per capita meat consumption at 46kg not far off from developed countries levels like Norway, which had a per capita consumption of 66kg in the same period. The latest figure we could get – 2009 estimates, shows that the gap has narrowed significantly, with the per capita meat consumption of 59kg and 66kg for South Africa and Norway, respectively (FAO, 2013).

Giving that greenhouse gas emission reductions are as of immense importance as the long term conservation of aquatic resources for the well-being of future generations, the question however is how sustainable are the changes in meat consumption patterns across SEAFO countries. For the purpose of this paper, we refer only to economic sustainability by examining the existence and direction of the causal relationship between economic growth measured in per capita GDP and meat consumption for six SEFAO countries for the period 1990 and 2009. It is worth noting that historically, a shock in one country (South African political transition in 1994; Asian crisis in 1998; US financial crisis in 2007) spilled over onto other countries even though they have significant differences in terms of geographical, political and socioeconomic conditions. This is known as heterogeneity and cross-section dependence which have been shown to induce bias estimates (Pesaran, 2006). In order to control for these two issues we employ the bootstrap Granger causality procedure based on meta-analysis in heterogeneous mixed panels proposed by Emirmahmutoglu and Kose (2011). Besides its ability to mitigate the issues of heterogeneity and cross sectional dependence, the bootstrap methodology does not require testing for cointegration, hence avoiding the issue of pre-test bias that are expected in traditional causality approaches. The rest of the paper is organised as follows. Section 2 reviews the relevant literature on meat consumption-growth nexus. Section3 discusses the data and the preliminary analysis. Section 4 presents the methodology and the empirical results while Section 5 concludes.

2. Literature review on the nexus between meat consumption and economic growth

Factors that influence meat consumption include wealth, volume of livestock production and consumption, socioeconomic status of consumers and macroeconomics conditions (Mann, 2000; Speedy, 2003; OECD, 2015). This section reviews the transmission channels between meat consumption and economic growth based on which testable hypotheses regarding the direction of causality between these variables will be derived.

In the literature, increasing meat consumption has been largely attributed to rising living standard; improving diet being the main channel. The relationship between income and improving diets is not a new concept. In 1941, Bennett’s comparative studies of consumption of staple foods concluded that there is an inverse relationship between the percentage of total calories derived from cereals and other staple foods and per capita income (Kiernan, 2012). According to Rosegrant et al. (1999) economic growth in developing countries is changing consumption patterns from slower growth in per capita food consumption of grains to rapidly growing per capita of total meat consumption, combined with induced growth in cereal feed consumption.

On the other hand, economic development brings about urbanisation and improved life expectancy due to healthy diet. Moreover, globalisation has broadened consumers’ demand space and hence created an opportunity for developing countries to take advantage of trade opportunities (Taljaard et al., 2006). Thus, in line with economic prosperity and growing world population, meat consumption is expected to grow globally (DVA, 2012); a relatively higher income in developed and developing countries making it possible for consumers to purchase better quality foods. This means shifting from inexpensive foods such as wheat, maize meal and rice to saturated fat meat products such as beef, pork poultry and seafood. Interestingly, macroeconomic uncertainty and shocks to gross domestic product might also exert significant pressures on food prices with consequences on meat demand. A comparison of meat with other commodities shows that it is characterised by high production costs and high output prices (OECD, 2015).

Finally, this strand of literature seems to suggest that as income rises around the world, so does meat consumption, particularly in developing countries characterised by greater affluence (Meissner *et al*., 2013). There is, therefore, a prima-facia case for a causality running from economic growth to meat consumption. This, however, does not rule out the plausibility of neutral effect. In fact, rising meat consumption is likely to result in higher volatility of food prices with negative impact on food security (Herrmann, 2009) and hence on sustainable economic growth, so that the positive meat effect of economic growth might cancel out the negative one.

Conversely, rising meat consumption induces livestock production which is critical for poor people living in developing countries; it often contributes to achieving multiple livelihood objectives and provides ways out of poverty. In Africa, subsistence farmers use livestock for various purposes, ranging from being a valuable asset of wealth to being the main source of nutrition for maintaining health (Meissner *et al*., 2013). The health channel implies that meat consumption contributes to economic growth through the development of human capital whereas the wealth effect vindicates the growth induced role of meat consumption as investment. Increasing meat consumption might also come as a by-product of the economic growth through the development of meat industry and the related benefits in terms of job creation and government revenue expansion. This provides the rationale to consider a causality running from meat consumption to economic growth.

While the global meat industry provides food and a livelihood for billions of people, it should be noted that it also has significant environmental and public health consequences to the planet and its inhabitants (OECD, 2015). One of the main challenges due to excessive consumption of meat is the farming practises adopted by livestock farmers in an effort to meet the ever increasing demand. Unsustainable production practises lead to greenhouse gas (GHG) emissions, land degradation, impacts on ecosystem processes, biodiversity loss and unsustainable water requirement for meat production particularly in water scarce countries like South Africa. Scholtz et al. (2013) argues that livestock farming is the world's leading user of arable land resources. These environmental issues coupled with risks to health indicated earlier predict a downward pressure on sustainable economic growth as a result of increasing meat consumption. In these conditions, the net effect of meat consumption on economic growth will depend on the magnitude of the positive impact compared to the negative externalities.

To sum up, the literature on the relationship between meat consumption and economic growth has led different scenarios that are not mutually exclusive so as to provide four testable hypotheses regarding the direction of the causality as follows:

H1: Unidirectional causality from economic growth to meat consumption.

H2: Unidirectional causality running from meat consumption to economic growth.

H3: Bidirectional causality between meat consumption and economic growth.

H4: Absence of causality in any direction.

The contribution of this study is twofold. Unlike previous studies mainly focused on the determinants of meat consumption, to the best of our knowledge, our paper is the first attempt to explicitly test the causality between meat consumption and economic growth; hence helping determine the causal direction between the two variables. More importantly, we apply a recently developed panel Granger causality approach which helps account for two crucial econometric issues, namely heterogeneity and cross sectional dependence which have been shown to induce biased estimates if not controlled for. In addition, unlike traditional causality approaches, the bootstrap does not require testing for cointegration, hence preventing the issue of pre-test bias (Emirmahmutoglu and Kose, 2011). While the empirical procedure used in the closest studies checks for correlation amongst variables which however does not necessary imply causal linkages, the implementation of this methodology is the first such attempt in the meat literature and therefore makes this study a substantial contribution.

3. Data description and preliminary analysis

The empirical investigation uses meat consumption data from Food Agricultural Organisation (FAO), FAOStat online statistical service and data compiled by the World Resources Institute[1] and measured in kg per person. The real GDP per capita growth obtained from the World Bank database, the World Development Indicators (WDI). Six SEAFO countries are selected over the period 1990 to 2009[2]. The use of real per capita GDP growth instead of real GDP is more appropriate as it proxies the leaving standard which is believed to affect meat consumption.

Table 1 displays the summary statistics for the two variables across selected countries from which it emerges that Norway and Angola have the highest and the lowest average meat consumption of 59.850kg and 16.65 kg per person, per year, respectively. It is worth noting that unlike Angola and Namibia, the average meat consumption of South Africa follows closely that of advanced economies with 43.295kg/per person. Conversely, South Korea and South Africa show the highest and lowest average growth rate of real GDP per capita of 4.896% and 0.621% per annum, respectively. Furthermore, the meat consumption series are approximately normal as the Jarque-Bera test could not reject the null of normality for all countries at the conventional level of significance. Similarly, with the exception of Angola, Japan and South Korea, the GDP growth series turn out to be approximately normal for the remaining countries.

Per capita meat consumption data show high level of heterogeneity (Figure 2). Developed economies (Japan, Norway and the South Korea) and developing countries (Angola, Namibia and South Africa) have witnessed periods of strong meat consumption per capita. In the developed group, while the average meat consumption growth in Japan and to some extent in South Korea tend to be relatively decreasing over time, Norway has experienced an increasing trend in meat consumption from 2000 upwards. From the developing group, South Africa and Angola, to a less extent, depict an increasing growth rate of meat consumption on average, whereas Namibia reached the highest consumption growth in the sub period (1995-1999) followed by the decline afterward. Consequently, before carrying out the causality test, it is

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[1] http://www. Wri.org

[2] Though meat consumption data are available from1960 to 2009, it is worth noting that Namibia achieved its independence in 1990 before joining the SEAFO. This justifies the decision to restrict our sample period to 1990-2009. More importantly, because of the permanent changes occurred in the euro area in terms of number of member countries during the selected period, the empirical analysis did not include EU. In fact, before 1990, the EU consists of 15 countries. The largest historical enlargement happened in 2004; bringing the number to 25 and subsequently to 27 when Bulgaria and Romania joined EU in 2007.

important to find out whether the slope coefficients are homogenous or heterogeneous so as to impose restrictions on the estimated parameters.

Table 1. Descriptive statistics

Country	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Panel A: summary statistics of per capita meat consumption								
Angola	16.65	15.85	23.700	12.300	3.184	0.677	2.646	1.633
Japan	43.600	44.200	46.900	38.800	2.552	-0.531	2.111	1.601
Namibia	28.535	29.700	42.800	15.200	7.396	-0.294	2.596	0.425
Norway	59.850	61.100	69.000	49.700	5.473	-0.273	2.088	0.942
South Africa	43.295	40.850	58.600	35.700	6.593	1.294	3.458	**5.759***
South Korea	43.555	44.250	56.400	25.200	9.243	-0.303	2.128	0.938
Panel B: Summary statistics of real per capita GDP growth								
Angola	2.932	2.795	18.506	-27.145	10.059	-1.124	5.227	**8.350****
Japan	0.832	1.311	5.212	-5.418	2.169	-0.932	5.101	**6.575****
Namibia	1.617	1.182	11.032	-4.469	3.388	0.768	4.342	3.471
Norway	1.993	1.982	4.822	-2.867	1.857	-0.756	3.836	2.488
South Africa	0.621	0.981	4.225	-4.157	2.475	-0.317	2.152	0.933
South Korea	4.896	4.876	9.946	-6.392	3.611	-1.465	5.868	**14.012*****

Note. 1. ***, **, and * indicate significance at the 0.01, 0.05, and 0.1 levels, respectively. The sample period is from 1990 to 2009. The Jarque-Bera test tests the null hypothesis of normality against the alternative of non-normality. The significance of the Jarque-Bera statistic indicates the rejection of the null of normality.

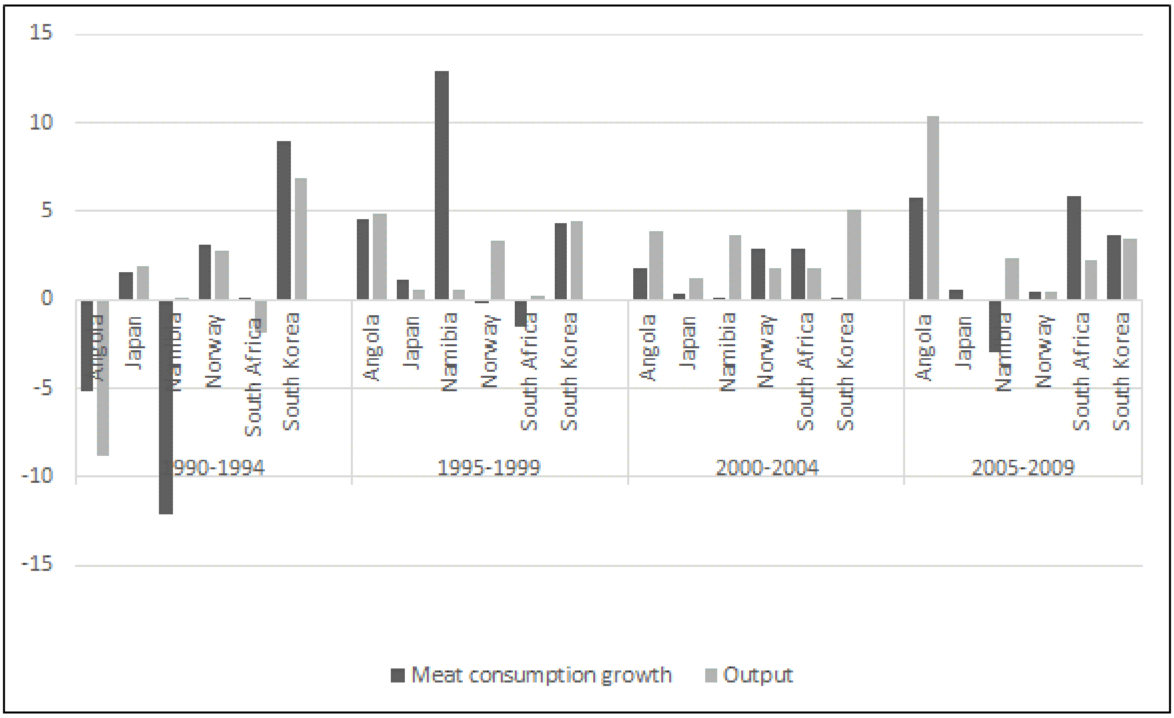

Figure 2: Average growth rates of per capita meat consumption and per capita GDP across selected countries.

Besides the heterogeneity, another important issue to consider in a panel causality analysis is the possible cross-section dependence across countries. This is because high degree of economic and financial integrations makes a country to be sensitive to external shocks from third countries. For instance, an unexpected shock on output in Norway may spill over onto South African economy with possible effects on household total consumption which in turn might play a significant role in detecting causal linkages between meat consumption and economic growth in South Africa. Given the above considerations, the panel causality requires checking for heterogeneity and cross sectional dependency across countries.

3.1. Testing heterogeneity

The most common way to test for the heterogeneity requires the estimation of the following panel model:

$$y_{it} = \alpha_i + \beta_i' x_{it} + u_{it} \text{ for } i = 1, 2, ..., N;\ t = 1, 2, ..., T \qquad (1)$$

where *i* is the cross section dimension, *t* is the time dimension, x_{it} is $k \times 1$ vector of explanatory variables, α_i and β_i are respectively the individual intercepts and slope coefficients that are allowed to vary across states. This procedure applies the standard *F* test to test the null hypothesis of slope homogeneity ($H_0 : \beta_i = \beta$ for all *i*) against the alternative hypothesis of heterogeneity ($H_1 : \beta_i \neq \beta_j$ for a non-zero fraction of pair-wise slopes for $i \neq j$).

The *F* test is valid for cases where the explanatory variables are strictly exogenous; and the error variances are homoscedastic. By relaxing homoscedasticity assumption in the *F* test, Swamy (1970) developed the slope homogeneity test on the dispersion of individual slope estimates from a suitable pooled estimator. Both the F test and Swamy (1970) test require panel data models where the cross section dimension (N) is relatively small and the time dimension (T) of panel is large[3]. The Swamy statistic which follows a chi-square distribution with N-1 degree of freedom is given by the following expression:

$$\tilde{S} = \sum_{i=1}^{N} \left(\hat{\beta}_i - \tilde{\beta}_{WFE} \right)' \frac{x_i' M_\tau x_i}{\tilde{\sigma}_i^2} \left(\hat{\beta}_i - \tilde{\beta}_{WFE} \right) \qquad (2)$$

where $\hat{\beta}_i$ is the pooled OLS estimator, $\tilde{\beta}_{WFE}$ is the weighted fixed effect pooled estimator, M_τ is an identity matrix, the $\tilde{\sigma}_i^2$ is the estimator of σ_i^2.

[3] Note that Pesaran and Yamagata (2008) proposed a standardized version of Swamy's test which is valid as $(N,T) \to \infty$. This is, however, not applicable to our dataset with N=6 and T=20.

Table 2. Heterogeneity test results

Panel 1. Regression of per capita meat consumption on per capita GDP growth	
Homokedasticity: F test	2.23**
Heteroskedasticity: Swamy test	40.80***
Panel 2. Regression of per capita GDP growth on per capita meat consumption	
Homokedasticity: F test	114.62***
Heteroskedasticity: Swamy test	1569.52***

Note: ***, **, and * indicate significance at the 0.01, 0.05, and 0.1 levels, respectively. Since these are the post estimation test, we consider both cases where GDP growth is the dependent variable (Panel 1) and that where meat consumption is the dependent variable (panel 2).

As displayed in Table 2, both the F test and Swamy test strongly reject the null hypothesis of slope homogeneity at the 1% and 5% level of significance; suggesting that the panel causality analysis by imposing homogeneity restriction on the variable of interest may result in misleading inferences. Therefore country specific characteristics should be taken into account.

3.2. Testing cross-sectional dependency

The Lagrange multiplier (LM hereafter) test of cross-sectional dependence proposed by Breusch and Pagan (1980) has been extensively used in empirical studies. This procedure tests the null hypothesis of no-cross section dependence ($H_0 : Cov(u_{it}, u_{jt}) = 0$ for all t and $i \neq j$) against the alternative hypothesis of cross-section dependence ($H_1 : Cov(u_{it}, u_{jt}) \neq 0$, for at least one pair of $i \neq j$). As in the case of the heterogeneity test, the LM statistic is computed using estimates of the panel model in equation (1) as follows:

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \tag{3}$$

where $\hat{\rho}_{ij}$ is the sample estimate of the pair-wise correlation of the residuals from Ordinary Least Squares (OLS) estimation of equation (1) for each *i*. Under the null hypothesis, the *LM* statistic has asymptotic chi-square with $N(N-1)/2$ degrees of freedom. It is important to note that the LM test is valid for N relatively small and T sufficiently large which is compatible with the structure of our dataset on 6 countries over 20 years (that is, N=6 and T=20).

It appears from Table 3 that the null hypothesis of no cross-sectional dependency is strongly rejected in favour of the alternative of cross-sectional dependency at the 1% level of significance, and this irrespective of whether error variance is constant (homokedasticity) or not (heteroskedasticity). These results indicate that a shock originating in one SEAFO country is likely to spill over onto others; information which should not be ignored when examining the causal linkages between meat consumption and economic growth.

Table 3. Cross sectional dependence test results

Panel 1. Regression of per capita meat consumption on per capita GDP growth	
Homokedasticity: LM test	41.496^{***}
Heteroskedasticity: LM test	39.573^{***}
Panel 2. Regression of per capita GDP growth on per capita meat consumption	
Homokedasticity: LM test	136.766^{***}
Heteroskedasticity: LM test	151.219^{***}

Note: ***, **, and * indicate significance at the 0.01, 0.05, and 0.1 levels, respectively. Since these are the post estimation test, we consider both cases where GDP growth is the dependent variable (Panel 1) and that where meat consumption is the dependent variable (panel 2).

4. Panel Granger causality analysis

The causality analysis in this paper follows Emirmahmutoglu and Kose (2011) who suggest a bootstrap Granger causality in heterogeneous mixed panels based on the Meta analysis of Fisher (1932). This choice relies on the above established relevance of heterogeneity and cross sectional dependence across SEAFO countries; issues that are not controlled for in existing causality approaches such as that proposed by Kónya (2006). In their procedure, Emirmahmutoglu and Kose (2011) extended the lag augmented VAR (LA-VAR) approach by Toda and Yamamoto (1995), which uses the level VAR model with extra *dmax* lags to test Granger causality between variables in heterogeneous mixed panels. Based on simulations studies, they demonstrate that the performance of LA-VAR approach under both the heterogeneity and cross-section dependency seem be satisfactory for the entire values of T and N.

Consider a level VAR model with $k_i + d\max_i$ lags in heterogeneous mixed panels:

$$x_{i,t} = \mu_i^x + \sum_{j=1}^{k_i + d\max_i} A_{11,ij} x_{i,t-j} + \sum_{j=1}^{k_i + d\max_i} A_{12,ij} y_{i,t-j} + u_{i,t}^x \qquad (4)$$

$$y_{i,t} = \mu_i^y + \sum_{j=1}^{k_i + d\max_i} A_{21,ij} x_{i,t-j} + \sum_{j=1}^{k_i + d\max_i} A_{22,ij} y_{i,t-j} + u_{i,t}^y \qquad (5)$$

where $i(i = 1,...,N)$ denotes individual cross-sectional units and $t(t = 1,...,T)$ denotes time periods, μ_i^x and μ_i^y are two vectors of fixed effects, $u_{i,t}^x$, $u_{i,t}^y$ are column vectors of error terms, k_i is the lag structure which is assumed to be known and may differ across cross-sectional units, and $dmax_i$ is the maximal order of integration in the system for each *i*. The bootstrap procedure by Emirmahmutoglu and Kose (2011) tests the causality from *x* to *y* in seven steps:

1. The maximal order $dmax_i$ of integration of variables in the system for each cross-section unit is determined based on the Augmented Dickey Fuller (ADF) unit root test (Dickey and Fuller, 1979 and 1981) and the lag orders k_i is selected via information criteria (AIC or SBC) by estimating the regression (5) using the OLS method.
2. Equation (5) is then re-estimated using the *dmaxi* and k_i under the non-causality hypothesis and calculate the residuals for each individual.

$$\hat{u}_{i,t}^y = y_{i,t} - \hat{\mu}_i^y + \sum_{j=1}^{k_i + d\max_i} \hat{A}_{21,ij} x_{i,t-j} + \sum_{j=1}^{k_i + d\max_i} \hat{A}_{22,ij} y_{i,t-j} \qquad (6)$$

3. The bootstrap residuals denoted as $\tilde{u}_t^*$ where $t = (1,...,T)$ are obtained using Stine's (1987) suggestion that residuals can be centered as follows:

$$\tilde{u}_t = \hat{u}_t - (T - k - l - 2)^{-1} \sum_{t=k+l+2}^{T} \hat{u}_t \qquad (7)$$

where $\hat{u}_t = (\hat{u}_{1t}, \hat{u}_{2t}, ..., \hat{u}_{Nt})'$, $k = \max(k_i)$ and $l = \max(d\max_i)$

Then, $[\tilde{u}_{i,t}]_{N \times T}$ is developed from these residuals by randomly selecting a full column with replacement from the matrix at a time to preserve the cross covariance structure of the errors.

4. The bootstrap sample of *y* is generated under the null hypothesis, that is,

$$y_{i,t}^* = \hat{\mu}_i^y + \sum_{j=1}^{k_i + d\max_i} \hat{A}_{21,ij} x_{i,t-j} + \sum_{j=1}^{k_i + d\max_i} A_{22,ij} y_{i,t-j}^* + \tilde{u}_{i,t}^* \qquad (8)$$

where $\hat{\mu}_i^y$, $\hat{A}_{21,ij}$ and $\hat{A}_{22,ij}$ are the estimations from step 3.

5. For each individual, the Wald statistics are computed to test the null hypothesis of no causality by substituting $y_{i,t}^*$ for $y_{i,t}$ and estimating equation (5) without imposing any parameter restrictions.
6. The Fisher test statistic (λ) is finally obtained using individual p-values (p_i) that correspond to the Wald statistic of the i^{th} individual cross-section as follows:

$$\lambda = -2\sum_{i=1}^{N} \ln(p_i) \qquad i = (1,...,N) \tag{9}$$

7. The bootstrap empirical distributions of the Fisher test statistics are further generated by repeating steps 3 to 5 many times and the bootstrap critical values are specified by selecting the appropriate percentiles of these sampling distributions.

As indicated earlier, the stationary property of the variables help determine the maximum order of integration of the two series (*dmax*$_i$) which will be then used in the causality analysis procedure. ADF unit root test results summarised in Table 4 indicate that the maximum order of integration is one for all countries except South Africa.

Table 4. ADF Unit Toot Test Results

Country	Per capita Meat Consumption			Per capita GDP Growth			*dmaxi*
	Level	First difference	Order of integration	Level	First difference	Order of integration	
Angola	-0.339	-3.543***	I(1)	-2.152	-4.236***	I(1)	1
Japan	-1.798	-3.105**	I(1)	-2.735	-4.006***	I(1)	1
Namibia	-1.721	-3.913***	I(1)	-3.593**	---------	I(0)	1
Norway	-1.597	-4.606***	I(1)	-0.821	-4.648***	I(1)	1
South Africa	1.464	-0.756	I(2)	-2.375	-2136	I(2)	2
South Korea	-1.243	-7.044***	I(1)	-4.228***	---------	I(1)	1

Note. ***, **, and * indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

The results from panel Granger causality tests are reported in Tables 5 and 6 along with the associated bootstrap critical values. Under both AIC and SBC lag selection criteria, the overall panel results approve a unidirectional causality running from per capita economic growth to meat consumption while strongly reject the opposite direction causality. This implies that wealthy countries tend to consume more meat. On the other hand, the absence of reverse causation from meat to economic growth is not surprising. In fact, due to the negative effect meat consumption exerts on both environment and health, increasing meat consumption is associated with unhealthy work force which induces a decline in productivity. This reveals that as nations increase their per-capita income, they initially consume more meat, but subsequently over time moderate their meat consumption despite increased income.

Table 5. Results for panel causality (Schwartz-Bayesian criterion)

H_0: per capita GDP growth does not Granger cause per capita meat consumption				
Country	Lag length	Wald Statistics	p-value	Granger causality Yes/No
Angola	1	12.560***	0.000	Yes
Japan	1	0.053	0.818	No
Namibia	1	0.056	0.813	No
Norway	1	0.082	0.775	No
South Africa	1	6.520**	0.011	Yes
South Korea	1	0.159	0.690	No
Fisher test value		Bootstrap critical values		
26.826**		10% / 5% / 1%		
		21.559 / 25.115 / 33.834		

H_0: per capita meat consumption does not Granger cause per capita GDP growth				
Country	Lag length	Wald Statistics	p-value	Granger causality Yes/No
Angola	1	4.883**	0.027	Yes
Japan	1	0.075	0.784	No
Namibia	1	0.006	0.936	No
Norway	1	0.225	0.635	No
South Africa	1	0.184	0.668	No
South Korea	1	0.244	0.621	No
Fisher test value		Bootstrap critical values		
10.501		10% / 5% / 1%		
		21.906 / 25.357 / 33.826		

Note. ***, **, and * indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

Table 6. Results for panel causality (Akaike information criterion)

H_0: per capita GDP growth does not Granger cause per capita meat consumption				
Country	Lag length	Wald Statistics	p-value	Granger causality Yes/No
Angola	1	16.083***	0.000	Yes
Japan	1	2.209	0.331	No
Namibia	1	0.056	0.813	No
Norway	1	0.082	0.775	No
South Africa	1	6.520**	0.011	Yes
South Korea	1	0.159	0.690	No
Fisher test value		Bootstrap critical values		
29.038**		10% / 5% / 1%		
		22.857 / 26.956 / 37.217		
H_0: per capita meat consumption does not Granger cause per capita GDP growth				
Country	Lag length	Wald Statistics	p-value	Granger causality Yes/No
Angola	1	6.898**	0.032	Yes
Japan	1	0.271	0.873	No
Namibia	1	0.006	0.936	No
Norway	1	0.225	0.635	No
South Africa	1	0.184	0.668	No
South Korea	1	0.244	0.621	No
Fisher test value		Bootstrap critical values		
10.501		10% / 5% / 1%		
		21.906 / 25.357 / 33.826		

Note. ***, **, and * indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

However, the individual country results remain contradictory to each other; the neutrality hypothesis being the most prevalent in the majority of SEAFO countries (Japan, Namibia, Norway and South Korea). This suggests that causality is not running in either direction. Thus, policies that encourage less meat intake can be anticipated without adverse consequences on economic growth. The results for South Africa is consistent with the panel result that economic growth causes meat consumption with no reverse causation. For Angola, the feedback hypothesis is confirmed showing that there is a bidirectional causality between meat consumption and economic growth. Angola has since the late 1990's experinced political stability, and is one of the fastest growing economies in the world. The implication of the rapid economic growth is high per capita income, which has jerked up meat consumption levels. Our results imply that the livestock sector in Angola is potentially contributing to economic growth due to demand-lead factors as Angolan people can now afford high-value livestock products. Thus, this finding appears plausible given Angola's context.

5. Conclusion

While seafood is considered as a more environmentally-friendly alternative to red meat consumption, the major objective of the SEAFO is the conservation and management of straddling and high seas stocks in the South East Atlantic. While increasing meat production and consumption could be considered as solution to ensure the long term conservation and sustainable use of the fishery resources in SEAFO's area of competence, there are implications on the negative impact of meat consumption on the environment and health implications which are not conducive to economic growth. A better understanding of what the trade-offs are in terms of balancing seafood as opposed to red meat production and consumption is required to assess the impact of shifts in production and consumption of the seafood to meat sector on economic growth.

In this paper, the causal relationship between meat consumption and economic growth is analysed in six countries (SEAFO members' countries with the exception of EU that has experienced permanent changes in terms of number of member countries since 1960s). The bootstrap panel Granger causality approach is employed, which accounts for both heterogeneity and cross section dependence across the countries for the period 1990-2009. The empirical findings support the unidirectional causality running from the economic growth to meat consumption. Consistently with the literature, these results are in support of the argument that rising living standard leads to significant increases in meat consumption.

When looking at the cross sections individually, South Africa is favourable to the overall panel results while the majority of countries show no support of a causal relationship in any direction, namely Japan, Namibia, Norway and South Korea. One of the reasons according to Gerben-Leenes et al. (2010) is that 'whenever and wherever economic growth occurs, food consumption shows similar change in direction.' However studies also show that the impact of urbanization, acceleration of economic growth trends in a country, in addition to income growth, rural-urban migration fuels meat consumption. For Norway for instance, the rate of economic growth is much more stagnant now than it was ten years ago, particularly in terms of income growth – which is currently stable and certainly not accelerating. However what has accelerated is urbanization and rural-urban migration. The trends in Japan are also similar to those in Norway. Although the same pattern is also evident in South Korea and Namibia, the main difference is in terms of income, where they is growth.

In the case of Angola, the feedback effect is found showing possible complementarities between meat consumption and economic growth. This is especially concerning as, even stronger than the trend of income growth in low-income countries, has been the overwhelming urbanization in the developing world. Considering that higher meat consumption occurs in youthful countries with growing economies (Gossard and York, 2003), an important area of future research would be to investigate whether age structure dynamics within developing countries influence meat consumption, as developing countries such as Angola and Namibia tend to have much younger populations than in higher income countries. In contrast, Norway, Japan and South Korea have relatively older population which could play a significant role on economic growth and meat consumption. Meat consumption is, however, a great concern for the environment. Therefore there is a need for countries to diversify into other forms of food and change the food policy accordingly. Further research should henceforth examine the substitutes to meat consumption and how they may affect the economic growth.

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