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ANALYSIS

Cross-national meat and fish consumption: exploring the effects of modernization and ecological context

Richard York[a,*], Marcia Hill Gossard[b]

[a] *Department of Sociology, University of Oregon, Eugene, OR 97403-1291, USA*
[b] *Department of Sociology, Washington State University, Pullman, WA 99164-4020, USA*

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Abstract

Production and consumption of meat and fish have serious consequences for global food security and the environment. An understanding of the factors that influence meat and fish consumption is important for developing a sustainable food production and distribution system. For a sample of 132 nations, we use ordinary-least-squares (OLS) regression to assess the effects of modernization and ecological context on per capita meat and fish consumption. We find that ecological conditions in a nation, such as resource availability and climate, influence meat and fish consumption. Additionally, indicators of modernization, particularly economic development, influence the consumption of both meat and fish. However, the effect of economic development on consumption patterns is distinctly different among geographic regions. We conclude that in order to understand national dietary patterns, researchers need to take into account not only ecological context and economic development, but also regional/cultural factors.

Keywords: Food consumption patterns; Diet; Meat; Fish; Modernization; Human ecology

1. Introduction

Food consumption patterns, particularly meat and fish consumption, have serious consequences for environmental sustainability (Gerbens-Leenes and Nonhebel, 2002; Goodland, 1997; White, 2000). What factors influence the scale and composition of global food consumption? Here we examine cross-national variation in meat and fish consumption to assess the ability of two major perspectives—human ecology and modernization—to address this question. We undertake this task in three steps. First, we discuss the importance of studying meat and fish consumption. Second, we outline the empirical predictions of the human ecology and modernization perspectives. Finally, we operationalize these predictions and empirically assess the extent to which the perspectives explain cross-national variation in meat and fish consumption.

2. Why meat and fish consumption matter

The expected growth of the human population to over 9 billion people by the middle of this century will likely increase pressure on the world's food supply.

* Corresponding author. Tel.: +1-541-346-5064; fax: +1-541-346-5026.

E-mail addresses: Rfyork@darkwing.uoregon.edu (R. York), Mgossard@wsu.edu (M.H. Gossard).

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Adding to the pressure generated by population growth, changes in diet among many of the world's people, particularly a rise in meat consumption, may constrain the ability of food production systems to meet demand (Goodland, 1997). The past 50 years saw the world's consumption of grain, beef, and mutton nearly triple (Brown et al., 1996). It is questionable whether similar growth in food consumption in the future can be accommodated without exacerbating environmental problems.

Meat production is resource intensive and of growing concern in environmental circles. Up to 10 times the quantity of resources (land, energy, and water) is needed to produce meat relative to equivalent amounts of vegetarian food (Durning and Brough, 1991; Dutilh and Kramer, 2000; Gerbens-leenes and Nonhebel, 2002; Goodland, 1997; Harrison and Pearce, 2000; Pimentel and Pimentel, 1996; White, 2000). Beef production in particular has serious environmental consequences, contributing to deforestation, desertification, and global warming (Durning and Brough, 1991; Harrison and Pearce, 2000; Myers, 1981; Subak, 1999). While not as often recognized for its environmental impacts, fish consumption also affects the global environment because it leads to the depletion of natural fish stocks and stimulates the expansion of aquaculture (Ellis, 2003; Harrison and Pearce, 2000; Jackson et al., 2001; Myers and Worm, 2003). For example, Myers and Worm (2003) estimate that, due to industrialized fishing, "large predatory fish biomass today is only about 10% of pre-industrial levels" (p. 280) (see also Jackson et al., 2001). Aquaculture threatens the environment because it requires many of the same inputs as feedlots (e.g. grain, energy) and leads to the conversion of coastal ecosystems, such as mangroves, to fish and shrimp ponds (Ellis, 2003; Harrison and Pearce, 2000). Relative to other foods, meat and fish, then, clearly have a high "diet impact ratio"—i.e. a high environmental impact per calorie of food supplied (White, 2000).

In addition to its effects on the environment, meat consumption also has serious social and economic consequences (White, 2000). While several hundred million people go hungry worldwide, 40% of the world's grain supply is fed to livestock (Harrison and Pearce, 2000). As meat consumption increases in many nations, the increased demand for grain by feedlots may further limit the supply available to the world's poorest people.[1] For example, increasing China's per capita consumption of beef to the level of the United States would require an additional 340 million tons of grain per year—which is roughly equal to the typical total annual US grain harvest (Brown, 1999). Due to the effects meat and fish production have on global food security and the environment, it is clearly important to understand the factors that influence meat and fish consumption.

Stern et al. (1997) argue that one important part of the environmental science research agenda should be to connect proximate causes of environmental degradation, such a meat production, with more ultimate causes, such as the social, political, and economic factors that lead to environmentally significant consumption (i.e. the consumption of commodities that have particularly serious effects on the environment). There is a substantial social science literature that examines the factors that influence the meat consumption behavior of individuals (Dietz et al., 1995, 1996; Gossard and York, 2003; Kalof et al., 1999; Sapp and Harrod, 1989; Zey and McIntosh, 1992). Additionally, agricultural economists have examined the factors that influence demand for different types of food at the aggregate (typically nation-state) level (Rosegrant et al., 2001). Economic analyses have led to sophisticated models used to project future demand for various food types, including meat (Rosegrant et al., 2001). They find that population growth, economic growth, and urbanization are the key factors influencing national food consumption trends (Rosegrant et al., 2001). Such models, however, neglect the ecological and sociocultural context of food consumption. Clearly, understanding the factors that influence meat and fish consumption requires the consideration of multiple perspectives. Here we develop an approach that incorporates the human ecology and modernization perspectives and takes into account potential differences among cultural/geographic regions.

[1] We recognize that hunger, malnutrition, and famine are not singularly, nor necessarily even primarily, the result of limited food production, but rather typically arise from a complex interaction of social, economic, and ecological forces. Sen (1983), for example, has demonstrated that people often go hungry in the midst of plenty.

3. Ecology and modernization

The human ecology perspective emphasizes the influence of ecological context—i.e. the biophysical environment—on social patterns (Freese, 1997; Harris, 1971, 1979; Hawley, 1950, 1986). Duncan (1959) argues that social organization and technology develop in an interactive relationship with the environment. The ecological conditions in which a society exists are, therefore, expected to have a substantial effect on food production and consumption. Key factors human ecologists identify as relevant to the dietary habits of a people include climate and resource availability (Diamond, 1997). In particular, it is expected that the availability of land will have a substantial influence on meat consumption, since meat production requires extensive area for grazing and/or feed grain production. Likewise, access to surface water is expected to be a substantial predictor of fish consumption. Although these expectations may seem fairly obvious, it is not entirely clear that consumption is dependent on the availability of resources within a nation in the modern globalized era, where the sites of production and consumption may be increasingly separated. Since wealthy countries often rely on resources of other nations in order to overcome production limitations and increase consumption levels, consumption may not always overlap with local production (see, for example, the "Netherland fallacy" discussed by Ehrlich and Holdren, 1971).

The modernization perspective identifies economic development and connection to global markets as key influences on production and consumption processes. The modernization perspective generally assumes that meat and fish consumption are determined by the economic means of a society to acquire these "superior goods"—i.e. it is assumed that as national affluence rises, meat and fish consumption will also rise since they are desirable, although expensive, food sources (Brown, 1995; Rosegrant et al., 2001). This approach also identifies urbanization as a key factor influencing food consumption patterns, since urban centers are more closely tied to world markets and, therefore, urban residents in a global market also have greater access to a diversity of food sources (Rosegrant et al., 2001).

Ecological and economic factors are often confounded with regional differences that may stem in part from cultural variation. It is, therefore, difficult to assess the independent effects on these factors on meat and fish consumption. It is clearly true, for example, that people in North America consume much higher quantities of meat than people on the Indian subcontinent. This may lead some observers to conclude that cultural differences explain the disparity in meat consumption levels. However, since there are also dramatic economic and ecological differences between these two regions, such an assessment would be premature without a more rigorous analysis. Clearly, it is important to assess the independent effects of ecological conditions, modernization, and regional characteristics on dietary patterns. For this reason we also take into consideration regional variation in meat and fish consumption that is not linked solely to economic development and ecology. To help further our understanding of the factors that influence national-level meat and fish consumption, here we provide an analysis using quantitative multivariate techniques.

4. Data and methods

We examine cross-national annual per capita consumption in kilograms (kg), calculated using a trade balance approach, of both meat (includes all types of meat except seafood) and fish (includes fish products and meals, molluscs, crustaceans, and solubles). Data for meat and fish are for 1998 and 1997, respectively, and are from the Food and Agriculture Organization (FAO) of the United Nations (UN), as presented in World Resources Institute, United Nations Environment Programme, United Nations Development Programme and World Bank (2000). We use a series of independent variables to put meat and fish consumption in economic and ecological context. Per capita GDP, in purchasing power parity, for 1997 (World Resources Institute, United Nations Environment Programme, United Nations Development Programme and World Bank, 2000)[2] and the percentage of the population living in urban areas in 1995 (UN Population Division and UN Development Program data

[2] Where more recent data are not available, we substitute slightly older data from World Resources Institute, United Nations Environment Programme, United Nations Development Programme and World Bank (1998). World Resources Institute (WRI) use World Bank data.

Table 1
Summary statistics of annual per capita meat and fish consumption by region (in kg)

Region (*N*)	Meat				Fish			
	Mean	S.D.	Minimum	Maximum	Mean	S.D.	Minimum	Maximum
Africa (34)	16	10	5	49	10	10	0	45
Asia (23)	28	23	3	90	18	19	0	66
Middle East (15)	36	26	10	100	10	8	1	29
West (60)	63	32	10	137	16	17	1	91
World (132)	42	33	3	137	14	15	0	91

presented in World Resources Institute, United Nations Environment Programme, United Nations Development Programme and World Bank, 1996) are included since they are widely recognized as influencing meat consumption (Rosegrant et al., 2001) and are the key variables of the modernization perspective. For ecological context, we include an indicator of resource availability: land area per capita for the meat analysis[3] and water area per capita, which includes continental shelf and inland water, for the fish analysis.[4] We also include an indicator of climate—the predominant latitude of the country, dummy coded into tropical, temperate, or subarctic/arctic[5]—since it influences the productivity of ecosystems. These two variables obviously provide only a rough indicator of ecological context. However, we believe they are sufficient for an exploratory analysis, especially in light of data limitations at the national level.

Recognizing that there may be distinct regional differences in dietary habits, perhaps due to cultural influences, independent of other factors, we categorize nations by geographic region. Since there is no single clear method for categorizing the cultural traditions of nation-states, we culturally divide the world in a simple manner, by categorizing each nation as being one of four cultural/geographic regions: the West (includes Europe and areas where indigenous peoples and/or their cultural heritages were largely replaced by European people and culture, such as the Americas, Australia, and New Zealand), (east) Asia, (sub-Sahara) Africa, and the Middle East (west Asia and north Africa). To the extent that culture develops from the particularities of history, ecological conditions, and economic relations, the cultural/geographic variable can only serve as a rough proxy. However, we believe the categories encompass regions with a moderate degree of historical, cultural, and religious cohesion and are useful for exploratory analyses.[6] We, of course, also recognize that there is considerable cultural heterogeneity within these categories.

Since we expect that the effects of economic development on diet may be mitigated by cultural/geographic differences, we assess the potential for an interaction effect between cultural category and per capita GDP. This interaction is estimated in the model by including a series of variables that are the dummy

[3] Due to data limitation, we do not differentiate between the various types of vegetative land cover (e.g. forest, grassland, etc.). The climate variable will in part control for these differences. Furthermore, humans have demonstrated a clear propensity to convert one type of ecosystem into another for food production purposes—e.g. the massive deforestation in Latin American to create pasture land (Myers, 1981)—suggesting that the "naturally" occurring vegetative cover in an area does not entirely limit the potential for various productive uses. We, of course, recognize that land area and climate are not fully sufficient indicators of resource availability and that more refined indicators could improve on our exploratory approach.

[4] Land area data are from World Resources Institute, United Nations Environment Programme, United Nations Development Programme and World Bank (1998). Water area data are from FAO Fishery Resources Division as presented in Prescott-Allen (2001). Note that for most nations continental shelf area makes up the vast majority of water area. For approximately half the nations in our sample data are not available for inland water area. For nations with data available on inland water area, we calculated the average water area as a percentage of land area. We used these results to estimate the inland water area of nations for which data are not available on inland water area. Note that using only continental shelf area in the analysis below does not substantively alter our results.

[5] Nations where the preponderance of land is at greater than 55° latitude are coded as "subarctic/arctic," nations where the preponderance of land is at less than 30° latitude are coded as "tropical," and all other nations are coded as "temperate."

[6] Note, for example, that the categories we use allow for assessing whether nations dominated by the Western cultural tradition have a particular propensity for exploiting the environment in general and animals in particular, as is suggested by some authors (Devall and Sessions, 1985; Singer, 1975).

Table 2
Annual per capita meat and fish consumption in kilograms

African nations	Meat	Residual (meat)	Fish	Residual (fish)
Angola	11	− 4	7	− 3
Benin	15	4	9	1
Botswana	32	− 5	6	− 13
Burkina Faso	11	1	1	− 7
Cameroon	15	− 1	9	1
Central African Republic	24	4	4	− 5
Chad	10	− 6	7	− 2
Congo, Democratic Republic	17	6	6	− 2
Congo, Republic	5	− 17	25	18
Côte d'Ivoire	11	− 4	11	2
Ethiopia	10	5	0	− 9
Gabon	49	14	45	21
Gambia	7	− 3	24	14
Ghana	8	− 4	23	14
Guinea Bissau	15	7	3	− 13
Kenya	13	3	5	− 4
Lesotho	16	6	4	− 6
Madagascar	18	8	8	− 2
Malawi	5	− 1	6	− 3
Mali	19	6	10	1
Mauritania	23	− 12	14	3
Mozambique	5	− 7	2	− 7
Namibia	36	− 4	12	− 14
Niger	12	0	1	− 8
Nigeria	12	0	6	− 2
Senegal	18	4	36	28
Sierra Leone	5	− 5	13	6
South Africa	34	− 4	8	− 6
Sudan	21	8	2	− 9
Tanzania	10	2	10	2
Togo	11	0	17	9
Uganda	11	5	10	0
Zambia	12	− 4	8	1
Zimbabwe	11	− 3	3	− 6
Asian nations				
Armenia	22	− 15	1	− 7
Azerbaijan	16	− 17	1	− 6
Bangladesh	3	− 9	11	− 1
Cambodia	15	2	9	− 4
China	47	19	26	13
India	4	− 11	5	− 7
Indonesia	9	− 10	18	1
Japan	42	− 22	66	9
Kazakhstan	41	− 2	3	− 8
Korea Republic	38	− 14	51	17
Kyrgyzstan	38	7	1	− 9
Laos	14	− 1	9	− 3
Malaysia	52	23	56	28
Mongolia	90	29	0	− 9

Table 2 (*continued*)

African nations	Meat	Residual (meat)	Fish	Residual (fish)
Asian nations				
Myanmar	9	− 5	18	7
Nepal	10	− 1	1	− 10
Pakistan	14	− 2	2	− 8
Philippines	27	4	30	15
Singapore	79	20	34	− 28
Sri Lanka	5	− 9	20	6
Thailand	26	7	34	9
Uzbekistan	29	− 2	1	− 10
Vietnam	21	8	17	4
Middle Eastern nations				
Algeria	18	− 10	4	− 2
Egypt	21	16	10	3
Iran	24	− 6	5	− 2
Israel	65	− 22	23	6
Jordan	21	1	3	1
Kuwait	82	9	11	− 7
Lebanon	40	− 5	7	0
Morocco	19	0	8	3
Oman	36	7	24	2
Saudi Arabia	44	− 3	7	− 7
Syria	20	1	1	− 3
Tunisia	20	− 9	9	2
Turkey	19	− 16	7	1
United Arab Emirates	100	20	29	3
Yemen	10	15	7	0
Western nations				
Albania	25	− 15	1	− 5
Argentina	98	22	10	− 2
Australia	110	− 8	18	− 18
Austria	106	9	11	− 9
Belarus	63	8	1	− 5
Belize	52	12	7	− 19
Bolivia	47	6	2	− 6
Brazil	69	18	7	− 3
Bulgaria	63	11	3	− 2
Canada	99	1	22	− 20
Chile	62	− 18	20	6
Colombia	34	− 15	5	− 5
Costa Rica	42	0	6	− 6
Croatia	22	− 31	4	− 4
Czech Republic	83	15	9	− 2
Denmark	127	38	24	− 6
Dominican Republic	37	− 4	9	0
Ecuador	32	− 9	8	− 3
El Salvador	17	− 15	2	− 7
Estonia	59	21	19	1
Finland	69	− 8	33	5
France	100	− 1	28	8
Germany	87	− 14	13	− 4

(*continued on next page*)

Table 2 (*continued*)

African nations	Meat	Residual (meat)	Fish	Residual (fish)
Western nations				
Greece	82	9	27	13
Guatemala	20	− 14	1	− 9
Guyana	25	− 16	64	46
Haiti	10	− 14	3	− 6
Honduras	17	− 13	4	− 5
Hungary	79	20	4	− 4
Iceland	70	− 32	91	10
Ireland	111	17	15	− 9
Italy	88	− 7	22	4
Jamaica	55	20	12	1
Latvia	37	3	11	− 3
Lithuania	48	13	15	2
Macedonia	30	− 18	4	− 1
Mexico	51	− 3	11	0
Moldova Republic	19	− 22	1	− 4
Netherlands	106	5	15	− 2
New Zealand	137	43	24	− 3
Nicaragua	15	− 19	1	− 9
Norway	60	− 31	51	8
Panama	48	3	13	− 3
Paraguay	67	27	6	− 3
Peru	32	− 13	27	18
Poland	72	15	12	4
Portugal	85	13	59	42
Romania	56	7	2	− 5
Russia	45	5	22	5
Slovakia	77	17	5	− 4
Slovenia	88	17	7	− 5
Spain	111	26	41	27
Sweden	71	− 9	26	− 1
Switzerland	71	− 34	14	− 8
Trinidad and Tobago	28	− 21	12	1
Ukraine	30	− 17	9	5
United Kingdom	76	− 25	21	3
United States of America	122	2	21	− 4
Uruguay	110	38	8	− 3
Venezuela	44	− 16	20	10

Residuals are from regression analyses (see Table 3).

coded cultural region variables multiplied by per capita GDP, as is standard procedure for generating interaction terms (Hamilton, 1992).

We use ordinary-least-squares (OLS) regression, with per capita meat consumption and per capita fish consumption as our dependent variables. Table 1 presents summary statistics for the two dependent variables. Note that the correlation between meat and fish consumption is fairly weak ($r = 0.29$, $P < 0.001$), indicating the importance of analyzing them separately. Our sample includes a total of 132 nations, all the nations for which necessary data are available. See Table 2 for a complete list of nations, per capita meat and fish consumption in each nation, and the cultural/geographic category of each nation.

5. Results and discussion

Note that in addition to the OLS models, we also estimated a simultaneous equation model (not presented here)—which included meat consumption as an independent variable in the fish model and fish consumption as an independent variable in the meat model—using two-stage-least-squares regression to assess whether meat consumption affects fish consumption and vice versa. The effects of meat consumption on fish consumption and the effects of fish consumption on meat consumption were non-significant, even at the 0.10 alpha-level, suggesting that meat and fish consumption are not influenced by one another. The coefficients for other variables were highly similar to those from the OLS models, although some significance tests were different. We focus our interpretation on the OLS models, since they are more parsimonious and provide clearer results.

The OLS regression results are presented in Table 3.[7] Both models provide a good fit—the R^2 for the meat model is 0.81 and for the fish model is 0.53. Note that we have also run the models using a robust (iterative Huber/biweight) regression procedure. This alternative procedure does not produce substantively different results from those presented here, indicating that the models are not overly influenced by outliers in the residuals. Also note that the tolerance for no variable in either model is below 0.27, indicating that there is not excessive multicollinearity. Since this is an exploratory analysis, we present the residual terms from the regressions (see Table 2) so that they may be examined for clues as to other factors not included in the models that

[7] Note that we have also run models using log transformations of the dependent variables. Furthermore, we have run other models using per capita GDP in log form to allow for a potentially curvilinear relationship with meat and fish consumption. The results of these analyses do not suggest substantively different conclusions than those presented here. We present models with the variables in original units since they provide a good fit and the coefficients are easier to interpret.

Table 3
OLS regression results for both annual per capita meat and fish consumption in kilograms ($N = 132$)

	Meat		Fish	
	Coefficient	S.E.	Coefficient	S.E.
Subarctic/arctic[a]	− 7.24	6.22	5.37	4.58
Temperate[a]	11.37**	3.68	− 2.48	2.68
Land, p.c.	0.46**	0.15	–	–
Water, p.c.	–	–	1.38***	0.26
% Urban	0.22*	0.10	− 0.08	0.07
GDP, p.c.	2.67***	0.28	0.79***	0.21
Asia[b]	− 7.15	5.83	0.18	4.15
GDP × Asia[b]	− 1.49*	0.57	1.52***	0.41
Africa[b]	− 12.66*	5.62	− 0.87	4.04
GDP × Africa[b]	− 1.01	1.41	0.56	0.98
Middle East[b]	− 31.03***	7.70	− 2.51	5.55
GDP × Middle East[b]	1.32	0.78	0.28	0.56
y-intercept	13.52*	6.50	9.88*	4.60
R^2	0.81	–	0.53	–

[a] "Tropical" is the omitted category.
[b] "Western" is the omitted category.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.0001$.

may influence meat and fish consumption. However, we do not wish to impose post hoc explanations on the results and, therefore, refrain from extensive analysis of the residuals.[8]

There are several clear results from the meat analysis. First, consistent with expectations of the modernization perspective, we find that nations with highly urbanized populations consume more meat per capita than those with less urbanized populations. This is perhaps because in urbanized countries there is greater access to a diversity of food products and/or greater access to refrigeration, although the specific reason cannot be determined from this analysis. Furthermore, basic ecological factors also have a significant influence on meat consumption, supporting the claims of human ecologists. Per capita, nations in temperate regions consume nearly 19 kg/year more meat than subarctic/arctic regions and 11 kg/year more than tropical regions, controlling for other factors. People in temperate regions may eat more meat than people in subarctic/arctic and tropical regions because the temperate zone is more conducive to grain production, and surplus grain is necessary for the intensive feedlot production of meat. Therefore, people in subartic/arctic regions may eat less meat than those in temperate regions simply because meat is resource intensive to produce, and colder climates are less biologically productive, while people in tropical regions may eat less meat due to the nature of tropical soil and other ecological factors that inhibit grain production. The availability of land also has a significant influence on meat consumption—nations with more land per capita consume more meat per capita. From an ecological perspective this is expected, since animal husbandry depends on extensive areas of land for pasture and growing crops for animal feed (Pimentel and Pimentel, 1996).

The inclusion of interaction effect variables for cultural region and per capita GDP necessitates a complex interpretation of the effects of affluence and culture on meat consumption. Note that in the regression model the Western cultural region is the omitted category. This indicates that the constant (13.52) is the y-intercept for Western nations. The y-intercept for other cultural regions equals the sum of the y-intercept for Western nations and the coefficient for the appropriate cultural region. Likewise, the per capita GDP coefficient (2.67) is the increase in annual per capita meat consumption in kilograms for each $1000 of per capita GDP for Western nations. The slope for other regions equals the sum of the slope for Western regions and the appropriate interaction term. All cultural regions have a lower y-intercept than Western nations, which is statistically significant for Africa and the Middle East. The effect of per capita GDP on meat consumption is not significantly different from Western nations in the Middle East and Africa (i.e. the interaction terms for these two cultural regions are not significantly different from zero). However, in Asia the effect of per capita GDP on meat consumption is

[8] Although the examination of residuals does not allow for strong conclusions, the results do allow for very rough assessments of whether some factors not included in the models may play a role. For example, it may be suggested that predominantly Catholic nations consume more fish and less meat than predominantly Protestant nations (nations with long histories as predominantly Catholic or Protestant are lumped together in the Western cultural/geographic category because we do not wish to make a fine distinction for Western nations, while not doing so for other regions—e.g. Asia—with equal or greater within-group heterogeneity) implying that Catholic nations may tend to have positive residuals for fish consumption and negative residuals for meat consumption. No such pattern stands out in the residuals, suggesting that the Protestant/Catholic distinction does not play a major role at the nation-state level.

significantly less than in Western nations. In Asia a \$1000 increase in per capita GDP corresponds with an increase in annual per capita meat consumption of only 1.18 (2.67 − 1.49) kg, compared to 1.66 (2.67 − 1.01) in Africa, 2.67 in Western nations, and 3.99 (2.67 + 1.32) in the Middle East (see Fig. 1).

The results for the fish analysis differ somewhat from the meat analysis. Unlike in the meat analysis, latitude does not have a significant effect on fish consumption nor does the proportion of the population living in urban areas. Resource availability—water area per capita—does influence fish consumption; unsurprisingly, nations with more water area consume more fish.

The results show that fish consumption is influenced by cultural/geographical regions and that consumption trends cannot be explained by economic or ecological perspectives alone. The *y*-intercepts and the interaction terms for the Middle East and Africa are not significant, indicating that, controlling for other factors, Middle Easterners and Africans eat approximately the same amount of fish as Westerners and the effect of economic development on fish consumption is the same for all non-Asian nations. However, the interaction term for Asia is significant and positive, indicating that for each \$1000 of per capita GDP, Asians eat 2.31 (0.79 + 1.52) additional kilograms per year of fish, whereas Westerners eat only 0.79 additional kilograms (see Fig. 2). This contrasts with the findings regarding meat consumption. It appears that economic development spurs Asians to eat considerably more fish compared to other cultural regions, whereas economic development spurs non-Asian regions to consume considerably more meat than Asians.

The meat results suggest that Western nations are more likely to consume animal products than are other nations,[9] while the fish results suggest otherwise.

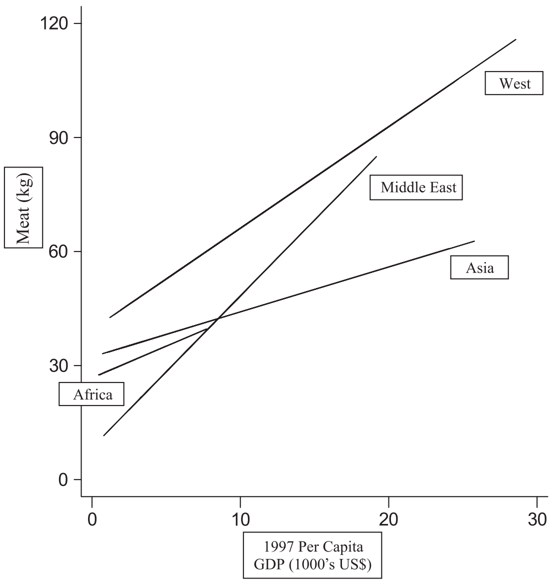

Fig. 1. Predicted per capita annual meat consumption in kilograms based on per capita GDP (purchasing power parity, US\$) for different cultural regions. Predictions based on OLS regression results (see Table 3), with land area per capita and % urban held constant at their respective cross-national means and latitude fixed at temperate. Each line is bounded by the observed ranges of per capita GDP for each cultural region.

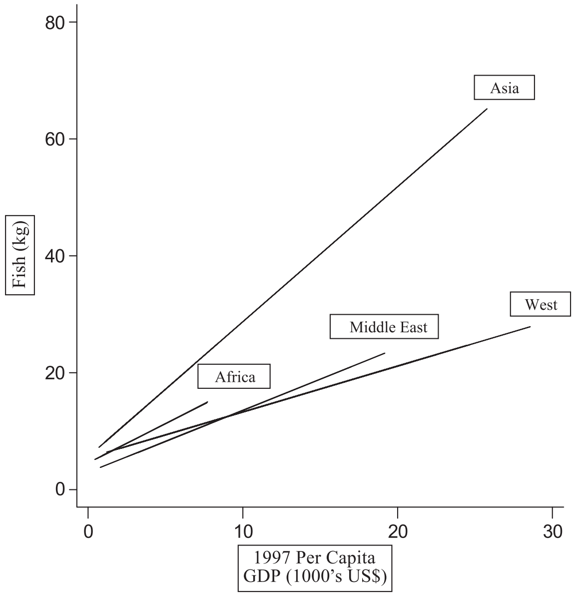

Fig. 2. Predicted per capita annual fish consumption in kilograms based on per capita GDP (purchasing power parity, US\$) for different cultural regions. Predictions based on OLS regression results (see Table 3), with water area per capita and % urban held constant at their respective cross-national means and latitude fixed at temperate. Each line is bounded by the observed ranges of per capita GDP for each cultural region.

[9] Note, however, that, controlling for other factors, Middle Eastern nations with a per capita GDP in excess of US \$23,500 are predicted to have slightly higher meat consumption than Western nations with equal per capita GDP (the situation is reversed when per capita GDP is less than US \$23,500 as it is for all Middle Eastern nations in our sample).

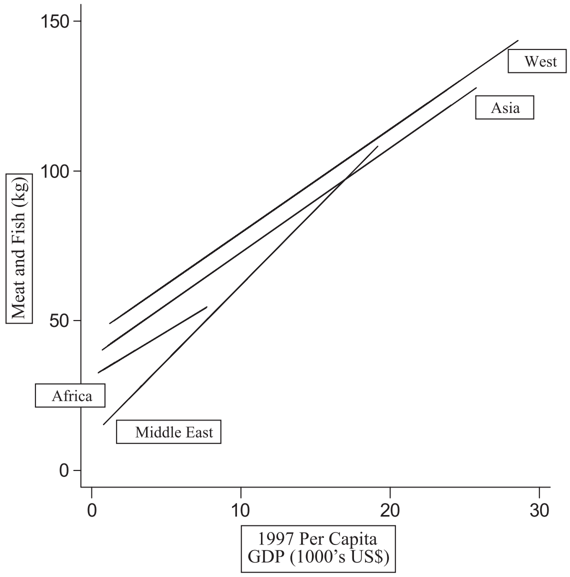

Fig. 3. Predicted per capita annual meat and fish consumption in kilograms based on per capita GDP (purchasing power parity, US$) for different cultural regions. Predictions based on OLS regression results (see Table 3), with water area per capita, land area per capita, and % urban held constant at their respective cross-national means and latitude fixed at temperate. Each line is bounded by the observed ranges of per capita GDP for each cultural region.

Nonetheless, when other factors are held constant, for all per capita GDP values within the range of observations the combined meat and fish consumption of Western nations is predicted to exceed that of all other nations (see Fig. 3).

6. Conclusion

Taken together, our results lead to three central conclusions. First, ecological conditions in a nation have a substantial influence on meat and fish consumption. These results serve as an important baseline, since globalization and increasing trade continue to separate people from local environments. The extent to which local environments influence food consumption patterns may change over time. Second, consistent with the research of agricultural economists, economic development appears to stimulate the expansion of both meat and fish consumption. However, our third conclusion is that the effect of economic development on meat and fish consumption depends on the cultural/geographic region of a nation.

Western nations have a tendency to consume more meat than other nations, particularly as their economies develop. In Asian nations economic development does not correspond with high meat consumption to nearly the degree as in Western nations. However, Asian nations do have a stronger tendency to consume fish at higher rates than other nations as their economies develop, indicating cultural predilections for certain types of animal foods. Similarly, the effect of urbanization on meat consumption also suggests a cultural explanation, since urbanization may lead to greater exposure to the culture of affluent, particularly Western, nations and therefore contribute to increased meat consumption. It is also important to consider that ecological factors may indirectly reflect cultural preferences that have developed due to the historical availability of resources and that may endure even when global markets make nations less dependent on the food supplied by their local environments. While we cannot draw definitive conclusions about the role of culture from these data, this exploratory research demonstrates the importance of examining the effects of cultural factors, in addition to economic and ecological factors, on meat and fish consumption.

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