Mathematics Internal Assessment

May 2019

The Nutritional Transition:
Protein per Capita and GDP per Capita

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Introduction

Statement of Task

As someone living in a country with ample access to a wide variety of food, I have the ability to tailor my diet to my personal preferences. For at least one week within a fortnight, my diet is entirely vegetarian and/or vegan, yet it is still balanced with an appropriate amount of macronutrients (carbohydrates, proteins, fats) to maintain a healthy lifestyle. In other countries around the world, starches and carbohydrates often form the basis of diets, as protein is more difficult to access, thus diet composition around the world can vary greatly.

In Geography class, we learned about the concept of the nutritional transition, which theorises that as countries develop economically, their meat and protein consumption and production will also increase, and overall dietary diversity will decrease (Codrington 258). BRICS countries are identified as countries with "emerging economies", and include Brazil, Russia, India, China and South Africa ("What is BRICS"). I have chosen to investigate China and India, as they are the two East Asian countries amongst this group and closest in geographical location to Hong Kong, therefore with more relevance to the area I am in. Additionally, as they have the world's largest populations at 1.4 and 1.3 billion respectively, any change that takes place within this demographic of people will have significant implications for the world's consumption of resources (Anil). I wanted to see if the concept of the nutritional transition would be demonstrated in the evolving dietary patterns in these two emerging, middle income countries with fast growing populations.

Plan of Investigation

This investigation will examine protein consumption (g/capita/day) as it changes over time, with respect to GDP per capita (Gross Domestic Product). The initial step for this investigation is to retrieve data for protein per capita and GDP from their respective UN Databases. Data for protein in diet per capita will be collected from the Food and Agriculture Organisation of the United Nations. The data for GDP per capita ($PPP) will be collected from UNData. Statistics for protein will be taken from 1973 to ensure sufficient data for graphing - this will provide 40 years worth of protein data, and thus 40 data points for each country.

The appropriate filters will be used on the FAO database to select all eight food groups deemed to have protein content. For per capita protein, out of available categories on the FAO website, animal products, pulses, tree nuts, meat, eggs, milk, fish, seafood will be counted as protein. The subdivided protein categories will then be summed to create a total amount of protein per capita per day for each year beginning in 1973. This data processing will happen for both countries. These two data sources were selected as the United Nations keeps track of comprehensive statistics from hundreds of countries, and is globally recognised for having extensive, detailed statistical data.

To process data, I will first calculate the median protein intake for each country, as it is the middle of the data set and will not be skewed by the outliers at the beginning and end of the data. The mean for the entire data set is not preferable in this situation as the data occurs over time, meaning the value may be impacted by outliers and will thus provide an inaccurate representation of the country.

Next, as an alternative to measure changes in protein intake over time, the '5 year mean' of protein intake for periods of five years will be calculated. These numbers will provide a summary of how protein intake may increase or decrease over time, which can then be linked to changes in GDP.

Such changes in both protein intake over time and protein intake with regards to GDP will be further demonstrated through the use of scatter plots. I will plot both China and India's protein consumption over time, and then plot protein against GDP. These graphs will provide a visual representation of potential relationships between these variables and will allow for interpretations of trends.

Finally, the Pearson's Product Moment Correlation Coefficient or r value will also be calculated by hand to determine whether there is a correlation between the variables, thus suggesting whether or not the 'nutrition transition' theory can be supported by these two countries. I will compare the correlation coefficients of both India and China to determine the changes in diet composition and GDP over time in a country. Based on the findings within the investigation, a conclusion will be formed.

After collecting the raw data from the UN Databases, I organised them by country into the following tables to make it easier for my simple and further processes to be conducted.

<u>Raw Data</u>
*See full data in the *Appendix*.
<u>Excerpt of Data</u>

CHINA		
Year	**Sum of g/capita/day**	GDP/capita ($PPP)
1973	15.53	
1974	15.61	
1975	15.76	
1976	14.99	
1977	14.91	
1978	15.65	...
1979	16.84	
1980	17.69	
1981	17.77	
1982	18.50	
1983	18.72	
...	...	...
1993	35.47	1461.61
1994	39.79	1668.58
1995	43.70	1869.47
1996	46.20	2070.77
1997	47.59	2277.21
1998	50.39	2458.63
1999	52.24	2664.49
2000	54.68	2933.31
2001	54.68	3226.85
2002	56.28	3551.66
2003	58.84	3961.27
2004	60.34	4455.21
2005	62.43	5092.56
2006	64.34	5883.72
2007	66.90	6863.98
2008	69.82	7635.07
2009	71.80	8374.43
2010	73.63	9333.12
2011	74.47	10384.37
2012	77.22	11351.06
2013	78.06	12367.97

INDIA		
Year	**Sum of g/capita/day**	GDP/capita ($PPP)
1973	20.20	
1974	19.54	
1975	25.35	
1976	28.40	
1977	27.17	
1978	26.42	...
1979	26.33	
1980	22.94	
1981	20.59	
1982	26.41	
1983	27.91	
...	...	...
1993	28.69	1290.35
1994	29.73	1378.50
1995	31.32	1485.03
1996	30.12	1595.71
1997	31.38	1657.41
1998	30.02	1746.49
1999	31.62	1895.44
2000	29.84	1977.65
2001	30.00	2083.82
2002	30.20	2159.36
2003	29.13	2336.47
2004	30.14	2549.27
2005	29.97	2830.41
2006	31.84	3138.63
2007	33.68	3484.88
2008	33.96	3637.64
2009	34.82	3920.01
2010	35.75	4315.60
2011	37.09	4635.88
2012	37.15	4916.49
2013	37.57	5250.51

After amassing all my raw data, I discovered UN database I collected the GDP per capita data from did not display GDP data for any countries prior to 1990. As such, this may be a limitation to be investigated further because it means when comparing GDP and protein intake, I can only compare 23 years worth of information rather than 40 years. This could prevent a more complete pattern of how GDP and protein intake are related from being drawn.

After organising my data, I will begin processing and analysing the results, beginning with the calculation of the median. As mentioned before, the median is the middle of a data set and will be calculated in this context to provide an initial snapshot of China and India's level of protein intake at the same point in time.

Data Processing and Analysis

Calculation of Median

In order to calculate the median for protein intake, the data was ordered from smallest to largest.

Median Protein Intake (g/capita/day) – China

As my data set has 40 points, an even number, the average of the middle two points will be taken to obtain the median.

Ordered Data for Protein Intake:
14.91, 14.99, 15.53, 15.61, 15.65, 15.76, 16.84, 17.69, 17.77, 18.50, 18.72, 20.36, 22.23, 23.04, 24.53, 26.54, 27.25, 28.32, 30.15, 32.20, **35.47, 39.79**, 43.70, 46.20, 47.59, 50.39, 52.24, 54.68, 54.68, 56.28, 58.84, 60.34, 62.43, 64.34, 66.90, 69.82, 71.80, 73.63, 74.47, 77.22, 78.06

35.47 and 39.79 are the 20th and 21st values within the set of 40 values.

Average of Two Middle Values:

$$\frac{(35.47+39.79)}{2}=37.63$$

The median intake of protein from 1973 to 2013 in China is 37.63 grams of protein per capita.

Median Protein Intake (g/capita/day) – India

Ordered Data for Protein Intake:
19.54, 20.2, 20.59, 22.94, 25.35, 26.33, 26.41, 26.42, 27.17, 27.66, 27.85, 27.91, 28.40, 28.42, 28.57, 28.69, 28.98, 29.03, 29.13, 29.73, **29.84, 29.86**, 29.97, 30.00, 30.02, 30.02, 30.12, 30.14, 30.14, 30.20, 31.32, 31.38, 31.62, 31.84, 33.68, 33.96, 34.82, 35.75, 37.09, 37.15, 37.57

29.84 and 29.86 are the 20th and 21st values within the set of 40 values.

Average of Two Middle Values:

$$\frac{(29.84+29.86)}{2}=29.85$$

The median intake of protein from 1973 to 2013 in India is 29.85 grams of protein per capita.

It is worthy to note that China's median protein intake is 7.78 grams higher than India's at the exact same point in time: the years 1993-1994. This discrepancy between the two countries will be shown to continue to widen through later mathematical processes. There are several reasons that this could occur – the most prominent being China was more economically advanced at that time than India was, with respective GDPs of 564.3 billion USD and 333 billion USD, and thus may have had better resources to provide food for the majority of the population ("GDP (current US$)").

The recommended protein intake per person per day depends on several factors, including the weight, height, age and sex of an individual (Pendick). A 6 month old baby requires different amounts of protein than an 80 year old male weighing 65 kilos, therefore it is important to note that the median protein intake per capita for each country may be lower or higher depending on the demographic in question ("Protein Intake"). As the particular data I used does not provide such demographic specifics, this may be a limitation to the data which will be discussed further in the validity section.

While median provides a brief comparison of protein intake in the two countries at one specific point in time, I chose to calculate the mean protein intake for each country over five year periods, in order to begin to see how protein intake has changed over time.

Calculation of Mean

The mean $\overline{X}$ of protein intake (g/capita/day) is $X_1,\ldots,X_n$ is $\overline{X}=\frac{\sum_{i=1}^{k} f_i x_i}{n}$, where $n=\sum_{i=1}^{k} f_i$

As this chosen data set progresses over time, the mean protein intake was calculated every five years, rather than the mean for the data overall, as this would be affected by outliers. This was calculated using the above formula in an Excel spreadsheet.

Mean Protein Intake (g/capita/day) Over Time – China and India

CHINA								
Year	1973-1977	1978-1982	1983-1987	1988-1992	1993-1997	1998-2002	2003-2007	2008-2013
5 year mean	15.34	17.31	21.78	28.89	42.55	53.65	53.65	53.65
INDIA								
Year	1973-1977	1978-1982	1983-1987	1988-1992	1993-1997	1998-2002	2003-2007	2008-2013
5 year mean	21.72	26.80	28.23	29.11	29.94	30.12	31.97	36.06

Sample Calculation of Mean
For the first five years of 1973 – 1977:

$$\frac{(15.53+15.61+15.76+14.99+14.91)}{5}$$
$$=15.34$$

The 5 year mean intake in China over time changes from 15.34 to 74.17 grams of protein per capita. Based on the 5 year mean alone, there are no decreases over time, only increases. After the years 1988-1992, the protein intake for increases dramatically by 8 or more grams per capita every five year increment. For example, the mean goes from 53.65 to 62.57 between 1988 and 2007, representing an increase of 8.92 grams of protein over this time period.

The 5 year mean intake in India over time changes from 21.72 to 36.06 grams of protein per capita. Unlike China, the increases in protein over time are not as consistent or as dramatic. Between 1993-1997 and 1998-2002 there was only a 0.18g increase in protein, while between 2003-2007 and 2008-2013 the increase was 4.09 grams, only half as much increase as China in any given five year period.

When comparing the mean over time for the two countries, the difference between China's first mean and last mean is far greater than the difference between India's first and last mean. This indicates that the change in protein per capita over time in China has a much more dramatic increase, whereas India only has a moderate increase of 14.34 grams within the 40 year period of data used.

As both country's 5 year means ultimately increase over time, this does begin to suggest that time and protein per capita in developing countries may have some relation.

Though the 5 year mean provides some picture of the changes in protein intake over time, no visual trends can be seen based on this process. Therefore, the next step is to construct scatter plots to further analyse and compare the data.

Creation of Scatter Plots

Protein Intake (g/capita/day) vs. Time vs. GDP in China

I created the following scatter plot of protein intake over time in China to better visualise the possible relationship between these two variables, with time as the independent variable and protein intake as the dependent variable.

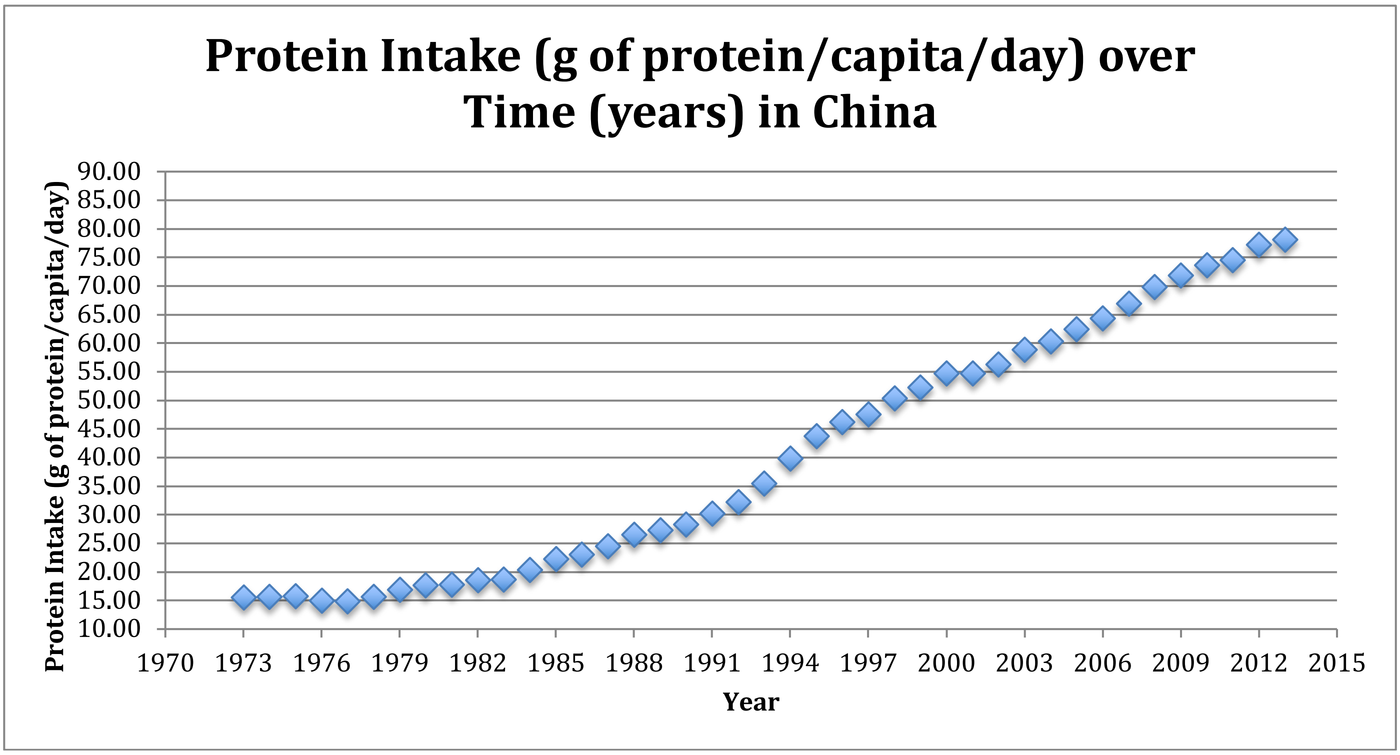

Figure 1. Protein Intake (g of protein/capita/day) over Time (years) in China.

Based on this graph, there appears to be a positive correlation between time and the amount of protein. According to the concept of the nutritional transition, as a country develops economically over time, the amount of disposable income the population has should also theoretically increase due to the growing global middle class (Rodhe). As this development occurs, the diet composition of the majority of individuals will also shift to containing more protein – this is because traditionally, grains and carbohydrates are cheaper to manufacture and to purchase, while most forms of meat protein are considered a high order good in developing countries (“What is the Nutrition Transition?”)

China therefore appears to exhibit some elements of this concept over the course of time. To determine whether protein intake and GDP demonstrate a relationship in China, I graphed both those variables together as well. GDP is the independent variable, while protein intake is the dependent variable.

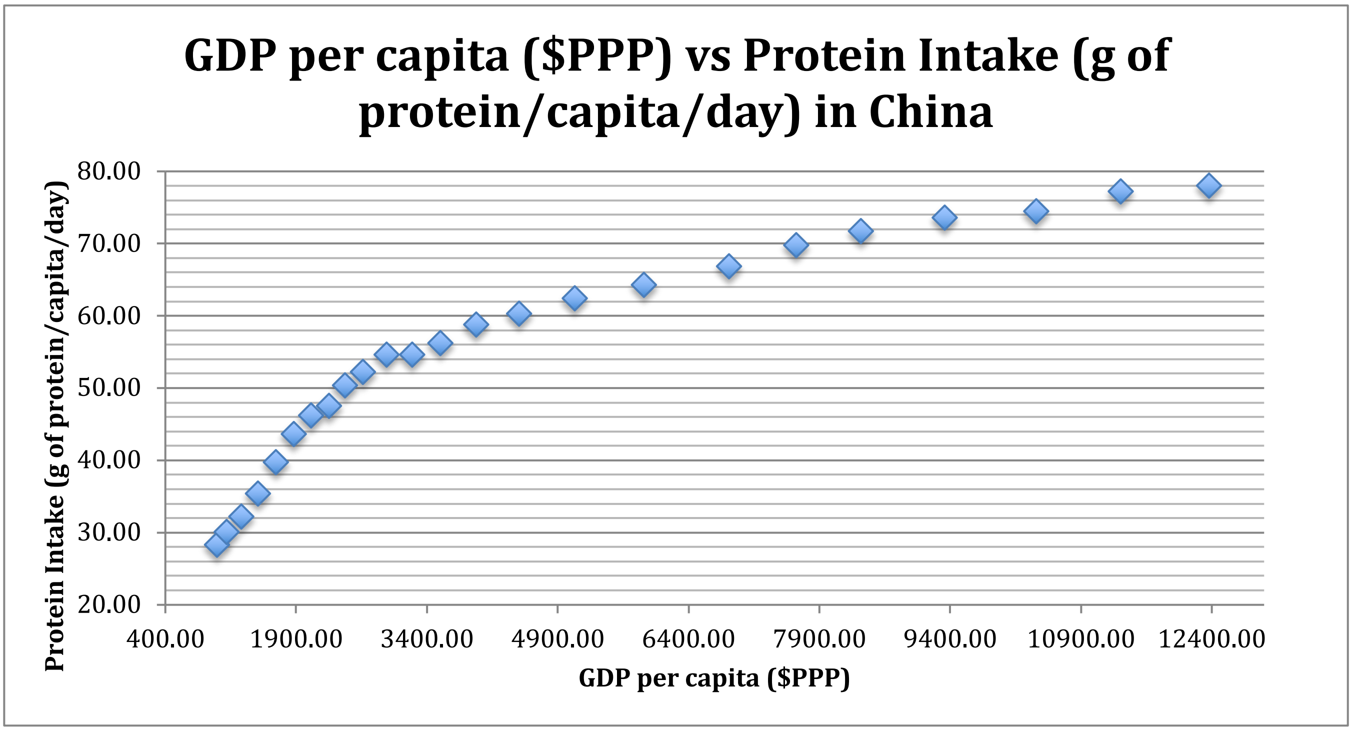

Figure 2. Protein Intake (g of protein/capita/day) vs GDP ($PPP) in China.

The trend between protein and GDP for China appears to still be strong – as GDP increases, so does the protein intake. There is an extremely rapid increase in protein intake when GDP is between $PPP 1000 and $PPP 4000, jumping from 28.32 grams to 54.68 grams. However, after GDP passes around $PPP 4900, the increase in protein intake begins to plateau, only increasing steadily to 78.06 grams. This is supported by the fact that China currently consumes approximately 28% of the world's meat, equivalent to an 800% increase in China's meat consumption since 1975 due to the "increasing affluence" of Chinese consumers (Codrington 259).

Protein Intake (g/capita/day) vs. Time vs. GDP in India

The same process was repeated when graphing the data obtained for India's protein intake.

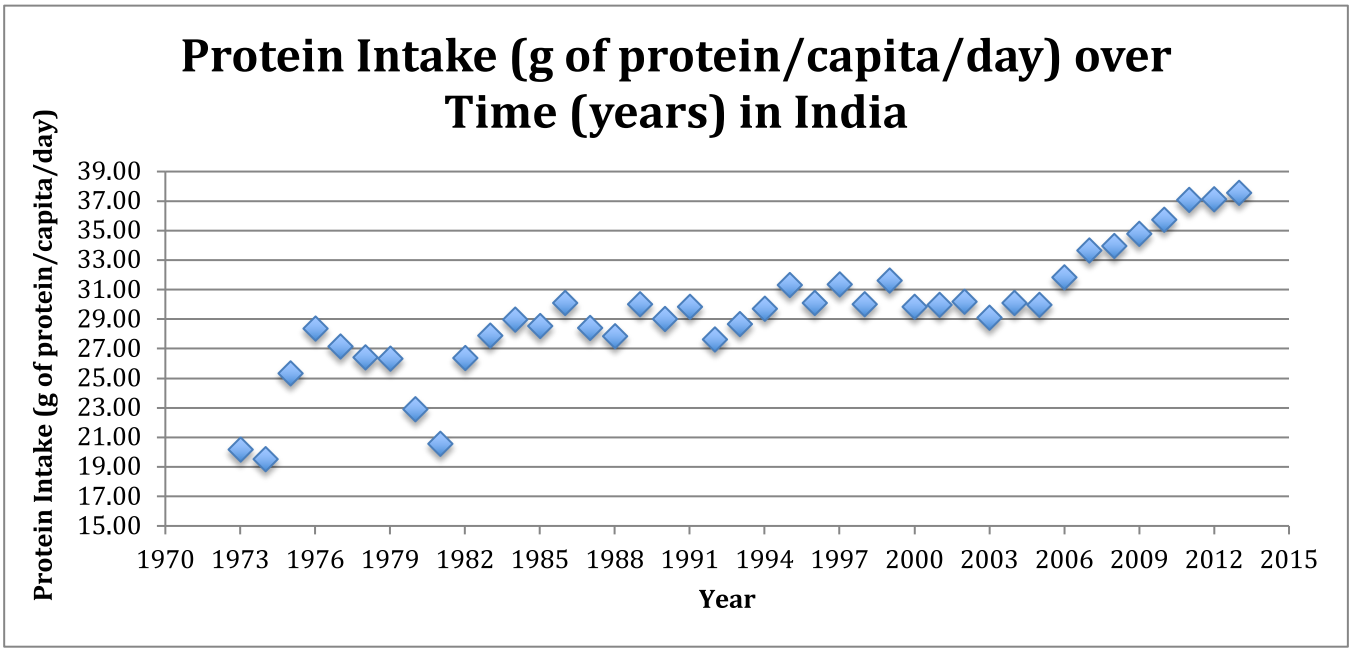

Figure 3. Protein Intake (g of protein/capita/day) over Time (years) in India.

Unlike the graph generated for China, the protein intake for India fluctuates considerably more over time, even though there appears to be an ultimate increase over the four decade period. The relationship between time and protein for India cannot be described as strong; it is a moderate positive correlation at best. Notable anomalies in this graph include the two large drops between 1979 and 1982 where intake falls to 23 grams per capita and below. These fluctations in the data may indicate a less stable country –whether economically, politically or socially, as the decade preceeding 1981 in India was known as 'the crisis years' (Panagariya). This resulted in a period of economic reform and increased stabilised economic growth, contributing to the overall growth of protein over time in India (Panagariya). Often, government policies play a role in determining a country's situation, which could impact the moderate correlation seen here.

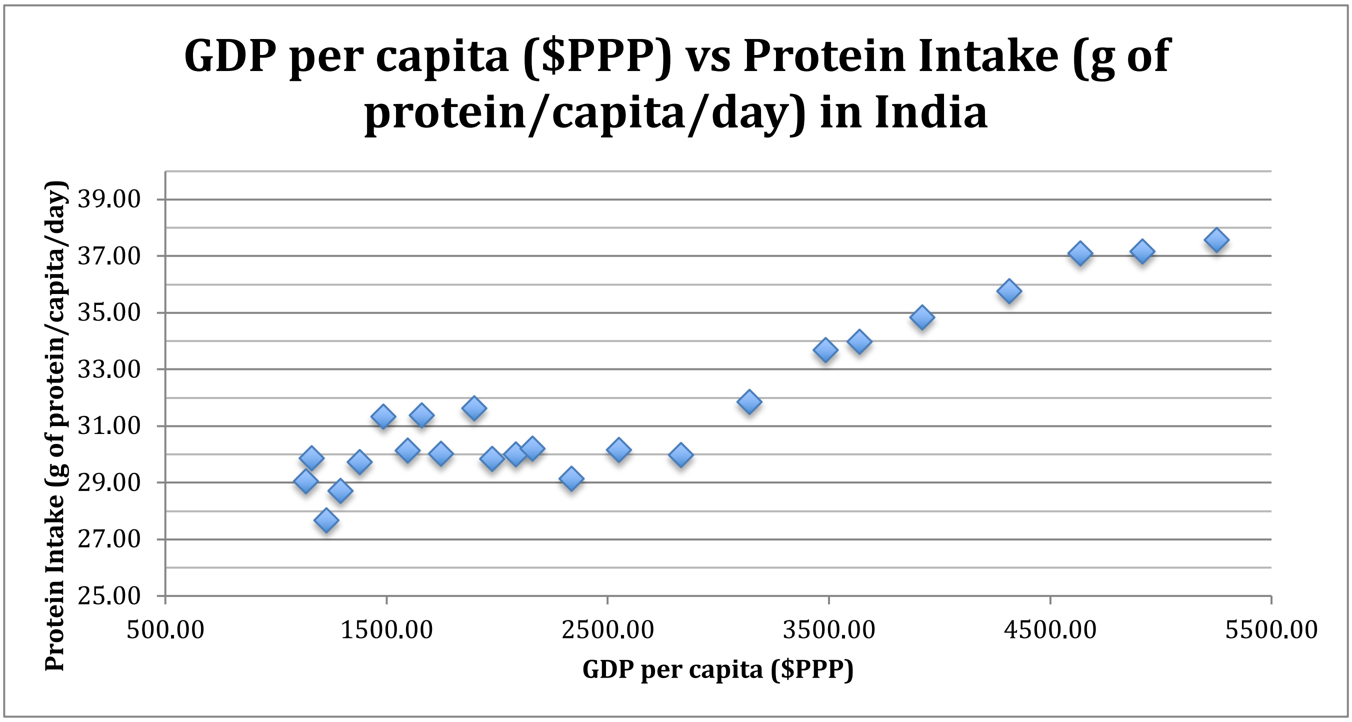

Figure 4. Protein Intake (g of protein/capita/day) vs GDP ($PPP) in India.

The relationship between protein intake and GDP in India is not as strong as that in China. The data points are far more spread out once GDP increases beyond $PPP 3500, and very clustered within $PPP 1000-2500. Visually, though there may appear to be an eventual increase in protein as GDP increases, the relationship seen on this graph is nowhere near as consistent as the same graph for China. Furthermore, it must be noted that the x axis scales (GDP) for this graph and the corresponding one for China are extremely different. This was intentionally done as the visual trend in data points for India would be very difficult to interpret if the scale was the same as China's, due to the fast differences in each country's GDP.

Though scatter plots allowed me to determine a good visual picture of how China and India compare in terms of protein intake, I will now calculate Pearson's Product Moment Correlation Coefficient to gain a final concrete understanding of changes in protein intake between these two countries.

<u>Pearson's Product Moment Correlation Coefficient – PMCC</u>

As I am attempting to find the strength of the relationship between the passage of time and protein intake per capita, I calculated the correlation coefficient for these two variables. The PMCC value will then allow me to compare the strength of any linear correlations found in both China and India's datasets. The PMCC value will be of particular note due to the differences in the scatter plots generated above for China and India – China had strong correlations between protein, GDP and time, while India had a noticeably spread of data points.

The following formula for can be placed in a table in Excel to calculate the r value for protein per capita over time by hand for both China and India, where the X value represents the year, and the Y value represents grams of protein per capita.

$$r = \frac{\Sigma(X - \bar{X})(Y - \bar{Y})}{\sqrt{\Sigma(X - \bar{X})^2 \Sigma(Y - \bar{Y})^2}}$$

<u>Partial PMCC Table – China</u>

x	**y**	**x – x̄**	**y – ȳ**	**(x – x̄)(y – ȳ)**	**(x – x̄)²**	**(y – ȳ)²**
1973	15.53	-20.00	-24.85	496.94	400.00	617.38
1974	15.61	-19.00	-24.77	470.57	361.00	613.41
1975	15.76	-18.00	-24.62	443.11	324.00	606.00
1976	14.99	-17.00	-25.39	431.58	289.00	644.50
...	...	...	...	...	...	...
2010	73.63	17.00	33.25	565.30	289.00	1105.76
2011	74.47	18.00	34.09	613.67	324.00	1162.33
2012	77.22	19.00	36.84	700.02	361.00	1357.40
2013	78.06	20.00	37.68	753.66	400.00	1420.00
ΣX = 81713.00	ΣY = 1655.46			$\Sigma(X-\bar{X})\Sigma(Y-\bar{Y})$ = 10161.85	$\Sigma(X-\bar{X})^2$ = 5740.00	$\Sigma(Y-\bar{Y})^2$ = 18658.65
$\bar{X}$ = 1993	$\bar{Y}$ = 40.38				$\sqrt{\Sigma(X-\bar{X})^2\Sigma(Y-\bar{Y})^2}$ = 10348.94	

$$r = \frac{10161.85}{\sqrt{5740 \times 18658.65}} = \frac{10161.85}{10348.94}$$
$$= 0.98192143$$

The value of r for China is 0.98192143, indicating a very strong positive correlation. This means as time progresses, grams of protein/capita/day also increases.

Partial PMCC Table – India

x	y	$x - \bar{x}$	$y - \bar{y}$	$(x - \bar{x})(y - \bar{y})$	$(x - \bar{x})^2$	$(y - \bar{y})^2$
1973	20.20	-20.00	-9.21	496.94	400.00	617.38
1974	19.54	-19.00	-9.87	470.57	361.00	613.41
1975	25.35	-18.00	-4.06	443.11	324.00	606.00
1976	28.40	-17.00	-1.01	431.58	289.00	644.50
...	...	...	...	...	...	...
2010	35.75	17.00	6.34	565.30	289.00	1105.76
2011	37.09	18.00	7.68	613.67	324.00	1162.33
2012	37.15	19.00	7.74	700.02	361.00	1357.40
2013	37.57	20.00	8.16	753.66	400.00	1420.00
ΣX = 81713.00	ΣY = 1205.81			$\Sigma(X-\bar{X})\Sigma(Y-\bar{Y})$= 1702.22	$\Sigma(X-\bar{X})^2$ = 5740.00	$\Sigma(Y-\bar{Y})^2$ = 678.48
$\bar{X}$ = 1993	$\bar{Y}$ = 29.41				$\sqrt{\Sigma(X-\bar{X})^2\Sigma(Y-\bar{Y})^2}$ = 1973.45	

$$r = \frac{1702.22}{\sqrt{5740 \times 678.48}} = \frac{1702.22}{1973.45}$$
$$= 0.86256225$$

The value of r for India is 0.86256225, which demonstrates a relatively strong positive correlation, confirming my observations of the data in the scatter plot. Though fluctuations occur in the data, particularly the observed sudden drops in the protein intake scatter plot for India, the overall trend as time progresses appears to be increasing. Therefore, based on the strength of the correlation indicated by this PMCC value, there appears to be some indication of increase in grams of protein as time progresses.

China has a very strong PMCC value, with India's value only slightly lower due to more variance within the data, meaning a reliable pattern for how the diet composition of MEDCs (More Economically Developed Countries) and how they change over time could potentially be established.

Conclusion
Based on the results obtained by this investigation, it can be concluded that protein intake could potentially be associated with change over time or increases in GDP in economically developing countries. While one country, China, showed very strong positive correlations between protein intake, time and GDP, India had slightly weaker correlations influenced by fluctuations in data.

The calculation of the median shows the inconsistency in protein intake between the two countries at the same snapshot in time. China had a median of 37.63, while India had a median of 29.85. The mean over five years was calculated to determine whether there was indeed a change in protein intake over time. The 5 year mean is a method of determining average increase in protein over time, and both countries show increase over time. The scatter plots drawn were able to visualise the contrast between the strength of the correlations. The data for China demonstrates a strong relationship between protein intake, GDP and changes over time, seen through the spread of the data. Contrastingly, the processes conducted for India demonstrate positive correlations with less strength than China's between protein, GDP and time.

In conclusion, the results of this investigation indicate the concept of the nutritional transition can be reasonably observed in the two target countries. However, it must be considered that though both India and China are prominent demographic populations that will undergo significant changes in the coming decades, the progress and trends seen in this country cannot be used to predict or model trends in development for all other countries of medium income.

Discussion of Validity

The validity of this investigation may have been influenced by other variables that were not ultimately tested. Economics are not the only factor that play into the changing diet composition of a country; policy decisions or level of corruption are other indicators that can influence the development of a country, and thus the proportion of protein in a citizen's diet. External factors such as financial crashes and livestock failure due to natural disasters are also unable to be factored into the data in this investigation. As such variables were not taken into account, the results from the investigation were limited.

Secondly, only two countries were selected to be tested, as they have the largest populations and predicted rates of growth both economically and demographically. However, the unique situation of China and India means any conclusions drawn from the data presented in this report may not apply to other developing countries. This limitation applies particularly to countries with far smaller populations and less financial stability. Therefore the usefulness and applicability of these results in being able to document a similar trend in other countries is restricted.

As mentioned in the body of the report, the data I used, despite being from a reputable database, still had limitations – namely there were external factors and variables not included in the dataset I was analysing. For the protein per capita data, it was established that the amount of protein needed would vary greatly depending on the demographics of an individual. If a country had a largely youthful population, the amount of protein intake required would differ from a country with an ageing population. The protein data collected from the FAO did not provide options to diffrentiate based on demographics of age, gender etc, which may have provided a more complete picture of protein intake across an entire country.

As an extension to this project, and to reduce the limitations discussed, it would be interesting to conduct further investigation into the relationships between protein, GDP and other variables *within* specific countries. For example, I could collect data from the government website of my country on the dietary consumption habits, income, and nationality of various districts in the area. I would then be able to examine any patterns found between differences in age, income, gender or nationality when compared with protein intake. I could also investigate the changes in proportion of other macronutrients, not just protein, most notably processed sugars and fats.

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Appendix

China - Data & Calculations

Sum of Protein per Year and GDP per capita; 5 Year Mean Calculation

Year	Sum of g/capita/day	GDP/capita ($PPP)	5 year mean (protein)
1973	15.53	data unavailable	15.34
1974	15.61		
1975	15.76		
1976	14.99		
1977	14.91		
1978	15.65		17.31
1979	16.84		
1980	17.69		
1981	17.77		
1982	18.50		
1983	18.72		21.78
1984	20.36		
1985	22.23		
1986	23.04		
1987	24.53		
1988	26.54		28.89
1989	27.25		
1990	28.32	986.57	
1991	30.15	1099.05	
1992	32.20	1268.27	
1993	35.47	1461.61	42.55
1994	39.79	1668.58	
1995	43.70	1869.47	
1996	46.20	2070.77	
1997	47.59	2277.21	
1998	50.39	2458.63	53.65
1999	52.24	2664.49	
2000	54.68	2933.31	
2001	54.68	3226.85	
2002	56.28	3551.66	
2003	58.84	3961.27	62.57
2004	60.34	4455.21	
2005	62.43	5092.56	
2006	64.34	5883.72	
2007	66.90	6863.98	
2008	69.82	7635.07	74.17
2009	71.80	8374.43	
2010	73.63	9333.12	
2011	74.47	10384.37	
2012	77.22	11351.06	
2013	78.06	12367.97	

PMCC – China

x	***y***	$x - \bar{x}$	$y - \bar{y}$	$(x - \bar{x})(y - \bar{y})$	$(x - \bar{x})^2$	$(y - \bar{y})^2$
1973	15.53	-20.00	-24.85	496.94	400.00	617.38
1974	15.61	-19.00	-24.77	470.57	361.00	613.41
1975	15.76	-18.00	-24.62	443.11	324.00	606.00
1976	14.99	-17.00	-25.39	431.58	289.00	644.50
1977	14.91	-16.00	-25.47	407.47	256.00	648.57
1978	15.65	-15.00	-24.73	370.91	225.00	611.43
1979	16.84	-14.00	-23.54	329.52	196.00	553.99
1980	17.69	-13.00	-22.69	294.93	169.00	514.70
1981	17.77	-12.00	-22.61	271.28	144.00	511.08
1982	18.50	-11.00	-21.88	240.65	121.00	478.61
1983	18.72	-10.00	-21.66	216.57	100.00	469.03
1984	20.36	-9.00	-20.02	180.15	81.00	400.68
1985	22.23	-8.00	-18.15	145.18	64.00	329.32
1986	23.04	-7.00	-17.34	121.36	49.00	300.57
1987	24.53	-6.00	-15.85	95.08	36.00	251.13
1988	26.54	-5.00	-13.84	69.19	25.00	191.46
1989	27.25	-4.00	-13.13	52.51	16.00	172.32
1990	28.32	-3.00	-12.06	36.17	9.00	145.37
1991	30.15	-2.00	-10.23	20.45	4.00	104.59
1992	32.20	-1.00	-8.18	8.18	1.00	66.86
1993	35.47	0.00	-4.91	0.00	0.00	24.08
1994	39.79	1.00	-0.59	-0.59	1.00	0.34
1995	43.70	2.00	3.32	6.65	4.00	11.04
1996	46.20	3.00	5.82	17.47	9.00	33.91
1997	47.59	4.00	7.21	28.85	16.00	52.03
1998	50.39	5.00	10.01	50.06	25.00	100.26
1999	52.24	6.00	11.86	71.18	36.00	140.73
2000	54.68	7.00	14.30	100.12	49.00	204.57
2001	54.68	8.00	14.30	114.42	64.00	204.57
2002	56.28	9.00	15.90	143.13	81.00	252.90
2003	58.84	10.00	18.46	184.63	100.00	340.88
2004	60.34	11.00	19.96	219.59	121.00	398.52
2005	62.43	12.00	22.05	264.64	144.00	486.33
2006	64.34	13.00	23.96	311.52	169.00	574.22
2007	66.90	14.00	26.52	371.32	196.00	703.47
2008	69.82	15.00	29.44	441.64	225.00	866.89
2009	71.80	16.00	31.42	502.77	256.00	987.40
2010	73.63	17.00	33.25	565.30	289.00	1105.76
2011	74.47	18.00	34.09	613.67	324.00	1162.33
2012	77.22	19.00	36.84	700.02	361.00	1357.40
2013	78.06	20.00	37.68	753.66	400.00	1420.00
[redacted]						

ΣX = 81713.00	ΣY = 1655.46
$\overline{X}$ = 1993	$\overline{Y}$ = 40.38

$\Sigma(X-\overline{X})\Sigma(Y-\overline{Y})$ = 10161.85	$\Sigma(X-\overline{X})^2$ = 5740.00	$\Sigma(Y-\overline{Y})^2$ = 18658.65
	$\sqrt{\Sigma(X-\overline{X})^2\Sigma(Y-\overline{Y})^2}$ = 10348.94	
	r **= 0.9819**	

India – Protein Data & Calculations
Sum of Protein per Year and GDP per capita; 5 Year Mean Calculation

Year	Sum of g/capita/day	GDP/capita ($PPP)	5 year mean (protein)
1973	20.20	data unavailable	21.72
1974	19.54		
1975	25.35		
1976	28.40		
1977	27.17		
1978	26.42		26.80
1979	26.33		
1980	22.94		
1981	20.59		
1982	26.41		
1983	27.91		28.23
1984	28.98		
1985	28.57		
1986	30.14		
1987	28.42		
1988	27.85		29.11
1989	30.02		
1990	29.03	1134.22	
1991	29.86	1160.46	
1992	27.66	1227.16	
1993	28.69	1290.35	29.94
1994	29.73	1378.50	
1995	31.32	1485.03	
1996	30.12	1595.71	
1997	31.38	1657.41	
1998	30.02	1746.49	30.12
1999	31.62	1895.44	
2000	29.84	1977.65	
2001	30.00	2083.82	
2002	30.20	2159.36	
2003	29.13	2336.47	31.97
2004	30.14	2549.27	
2005	29.97	2830.41	
2006	31.84	3138.63	
2007	33.68	3484.88	
2008	33.96	3637.64	36.06
2009	34.82	3920.01	
2010	35.75	4315.60	
2011	37.09	4635.88	
2012	37.15	4916.49	
2013	37.57	5250.51	

PMCC – India

x	y	$x - \bar{x}$	$y - \bar{y}$	$(x - \bar{x})(y - \bar{y})$	$(x - \bar{x})^2$	$(y - \bar{y})^2$
1973	20.20	-20.00	-9.21	184.20	400.00	84.82
1974	19.54	-19.00	-9.87	187.53	361.00	97.42
1975	25.35	-18.00	-4.06	73.08	324.00	16.48
1976	28.40	-17.00	-1.01	17.17	289.00	1.02
1977	27.17	-16.00	-2.24	35.84	256.00	5.02
1978	26.42	-15.00	-2.99	44.85	225.00	8.94
1979	26.33	-14.00	-3.08	43.12	196.00	9.49
1980	22.94	-13.00	-6.47	84.11	169.00	41.86
1981	20.59	-12.00	-8.82	105.84	144.00	77.79
1982	26.41	-11.00	-3.00	33.00	121.00	9.00
1983	27.91	-10.00	-1.50	15.00	100.00	2.25
1984	28.98	-9.00	-0.43	3.87	81.00	0.18
1985	28.57	-8.00	-0.84	6.72	64.00	0.71
1986	30.14	-7.00	0.73	-5.11	49.00	0.53
1987	28.42	-6.00	-0.99	5.94	36.00	0.98
1988	27.85	-5.00	-1.56	7.80	25.00	2.43
1989	30.02	-4.00	0.61	-2.44	16.00	0.37
1990	29.03	-3.00	-0.38	1.14	9.00	0.14
1991	29.86	-2.00	0.45	-0.90	4.00	0.20
1992	27.66	-1.00	-1.75	1.75	1.00	3.06
1993	28.69	0.00	-0.72	0.00	0.00	0.52
1994	29.73	1.00	0.32	0.32	1.00	0.10
1995	31.32	2.00	1.91	3.82	4.00	3.65
1996	30.12	3.00	0.71	2.13	9.00	0.50
1997	31.38	4.00	1.97	7.88	16.00	3.88
1998	30.02	5.00	0.61	3.05	25.00	0.37
1999	31.62	6.00	2.21	13.26	36.00	4.88
2000	29.84	7.00	0.43	3.01	49.00	0.18
2001	30.00	8.00	0.59	4.72	64.00	0.35
2002	30.20	9.00	0.79	7.11	81.00	0.62
2003	29.13	10.00	-0.28	-2.80	100.00	0.08
2004	30.14	11.00	0.73	8.03	121.00	0.53
2005	29.97	12.00	0.56	6.72	144.00	0.31
2006	31.84	13.00	2.43	31.59	169.00	5.90
2007	33.68	14.00	4.27	59.78	196.00	18.23
2008	33.96	15.00	4.55	68.25	225.00	20.70
2009	34.82	16.00	5.41	86.56	256.00	29.27
2010	35.75	17.00	6.34	107.78	289.00	40.20
2011	37.09	18.00	7.68	138.24	324.00	58.98
2012	37.15	19.00	7.74	147.06	361.00	59.91
2013	37.57	20.00	8.16	163.20	400.00	66.59
[redacted]						

ΣX = 81713.00	ΣY = 1205.81		$\Sigma(X-\overline{X})\Sigma(Y-\overline{Y})$ = 1702.22	$\Sigma(X-\overline{X})^2$ = 5740.00	$\Sigma(Y-\overline{Y})^2$ = 678.48
$\overline{X}$ = 1993	$\overline{Y}$ = 29.41			$\sqrt{\Sigma(X-\overline{X})^2\Sigma(Y-\overline{Y})^2}$ = 1973.45	
				r **= 0.8625**	