Regional Demands for Pulp and Paper Products

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ABSTRACT

The pulp and paper industry has experienced dramatic changes during the past several decades with large variations in world regional market shares of production capacity and consumption patterns. Based on panel data available (1961-2000) from the United Nations Food and Agricultural Organization, this paper estimates per capita regional demands for major pulp and paper products. Focusing on Asia, Europe, the North American Free Trade Agreement Area, and South America, the analysis finds that world paper consumption continues to increase but that there have been significant regional shifts in aggregate and per capita demands. Among the selected results, NAFTA product sectors are generally income inelastic and typically more inelastic than is than found in the other three regions. Per capita demands in South America are income elastic in most product sectors and in Europe demands in the Wrapping/Packaging sector are consistently income elastic. Per capita demands were generally found to be price inelastic and within a narrow range, -0.08 to -0.05. And urbanization is generally associated with elastic demands, with the noted exception of the Newsprint sector, where a 1% increase in urbanization reduces newsprint demands by nearly 2%. Inconsistent results for Asia, particularly in the Household/Sanitary and Wrapping/Packing sectors, and broad confidence intervals in Out-of-Sample forecasts for the Household/Sanitary sector suggest the need for additional research to better identify the important determinants of per capita regional demands in these product categories.

JEL Classifications: L6, L67, L73, R11

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Introduction

The US pulp and paper industry is a traditional manufacturing industry that has experienced significant structural changes during the past several decades. Between 1965 and 2000, US consumption of pulp and paper, as a proportion of world consumption, has fallen 13.3%, from 41.4% to 28.1%. And the current US GDP-share of paper products decreased from 75% in 1987 to 62% in 1997 (Bureau of Economic Analysis (BEA), http://www.bea.gov/bea/dn2/gdpbyind_data.htm). Consistent with these trends, the number of persons employed in the industry has fallen. Pulp, paper and paperboard mills employed 185,240 persons in 1999 which decreased to 177,450 in 2001 (Bureau of Labor Statistics (BLS), http://www.bls.gov/oes/home.htm). Among the factors contributing to the structural shift are the increasing number of paper alternatives such as plastics, e-paper, and other information technology innovations, rising incomes and increasing demands in developing regions of the world (particularly Asia), the outsourcing and offshoring by many U.S. manufacturing firms as they strive to lower their operating costs, and increasing capacity investments in developing parts of the world (most notably Asia and South America) as these areas seek to develop a globally competitive manufacturing sector.

The consumption of total pulp and paper products is positively correlated with gross domestic product. The more developed regions of the world, North America and Europe, have the highest per capita consumptions at 414.78 and 202.95 kg in 2001. And since these regions are in a more mature phase of the industry life cycle, one expects that income changes will have lower impacts upon pulp and paper demands relative to regions whose manufacturing sectors are in the early stage of the industry life cycle (Audretsch and Woolf (1986)). Asia and South America have much lower per capita consumption at 42.53 and 55.37 kg in 2001, respectively. Also, Asia (8.1%) and South America (4.8%) experience higher average growth rates of consumption per capita in since these regions are in an earlier stage of the industry life cycle.

Several studies have examined aspects of pulp and paper demands. In a U.S. regional market analysis of U.S. pulp and paper industry, Kaltenberg and Buongiorno (1986) estimated long run income elasticities of demand for paper , which ranged from a low of .69 for New England to a high of 1.36 in the West. For paperboard, the range was .63 in New England to 2.98 in the East South Central area.[1]

Using data for the period 1960-1991, Zhang and Buongiorno (1997) developed and estimated an Almost Ideal Demand System (AIDS) model for printing and publishing papers. Consumer demand for communication was stage one in their model and demands for printed materials, computers, and televisions and radios was stage two. The results suggested that printed materials and computers were

[1] With the exception of the East South Central and West regions, these estimates are similar to other studies. However, as Kaltenberg and Buongiorno (1986) noted, a concern with the analysis is the small number of observations (28) and the high degree of collinearity among the exogenous variables.

luxury goods (1.23 income elasticity for printed materials); the demand for printed materials was most sensitive to price and to income, independent of the price of computers and slightly complementary of the demand for the televisions and radios. Decomposition analysis showed that the growth in income per capita was the major determinant of the growth in demand for printing and publishing papers during 1982-1991.

And in a more recent paper, Chas-Amil and Buongiorno (2000) analyzed the demand for paper and paperboard in several countries of the European Union. Based upon a panel of fourteen European Union countries in 1995 and a time period that spanned 1969-1992, the authors estimated dynamic demand equations for newsprint, printing and writing paper, and other paper and paperboard.[2] For total paper and paperboard, newsprint, printing and writing paper, and other paper and paperboard, the authors estimated short run income elasticities to be .26, .39, .36, and .18 respectively. Long run elasticities for the same categories were estimated as .60, .63, 1.07, and .41.[3]

Hetemaki and Obersteiner (2001) used a Bayesian model, which incorporates industry experts' prior information about the future demand for newsprint, to compute projections for US newsprint demand through 2020. In related work, Hetemaki and Nilson (2005) find that information and communication technologies have had a large effect on all aspects of the forest products sector, including newsprint, communication paper, and paperboard and packaging. From their results, long run income elasticity for newsprint consumption turned negative, consistent with the findings of Hetemaki and Obersteiner (2001), falling from a range of (0.63%, 0.98%) before 1987 to (-0.22%, -0.44%) after 1987. Short run income elasticities, on the other hand, remained positive.

Li, Luo, and McCarthy (2004) investigated the demand pattern and structural changes during China's economic transformation, using instrumental variables estimations, cointegration analysis and error-correction models. Based upon annual data from the paper and paperboard industry in China, the authors found that after 1992, the own and cross price elasticity with respect to world market price increases (in absolute value) to -0.69 and .59, respectively. The estimated income elasticity for import demands is not statistically different from 1.0, while the own-price elasticity increased from -0.60 to -0.50 before and after 1992, respectively.

The present analysis contributes to the existing literature on pulp and paper demands in a number of important ways. First, noting the global shifts that are currently occurring in the production and consumption of pulp and paper, this analysis focuses upon regional demands that represent over 95% of

[2] The data source for the analysis was the United Nations Food and Agricultural Organization *Yearbook of Forest Products*, 1998. Although there were fifteen countries in the European Union in 1995, the analysis is based on fourteen countries because the FAO data set combined Belgium and Luxemburg.

[3] In their analysis, Chas-Amil and Buongiorno (2000) provide income elasticity estimates (Table 6, p. 997) from other studies. For newsprint, printing and writing paper, and other paper and paperboard, the estimates have ranges of (0.7 – 1.5), (1.0, 1.6), and (0.6 – 1.4), respectively.

world production and consumption. Second, in that much of the demand for pulp and paper products is derived, this study focuses upon per capita demand rather than total demand in each of the four regions. Third, the study is based upon panel data that cover four decades, from 1961–2000. Fourth, the analysis comparatively analyzes income sensitivities based upon parsimonious Engle and more general empirical demand models. And fifth, the study represents a broader set of product categories that include newsprint, printing and writing papers, household and sanitary papers, and wrapping and packaging papers. For each region and across the product categories, the analysis provides new information on income elasticities, finding that regional elasticities are not equally sensitive to changes in income.

1. Methodology

Consumer demand for pulp and paper products is the outcome of a more general problem whereby a consumer maximizes her economic welfare, subject to resource constraints, over all consumption goods and services. In the simplest of frameworks, let $z_{i,t}$ reflect individual i's consumption of pulp and paper products at time t and with associated price $p_{z,t}$, $x_{i,t}$ be the consumption of numeraire commodity x at time t with price $p_{x,t}$, and $I_{i,t}$ be consumer i's income at time t. Then consumer i's constrained welfare optimization generates a demand function for pulp and paper products which can be characterized as

$$(1) \qquad z_{i,t} = g_i(p_{z,t}, p_{x,t}, I_{i,t}; \phi_i)$$

where ϕ_i reflects consumer i's preferences which are assumed to be a function of socio-economic characteristics and other exogenous factors that generate demand shifts independent of included prices and income. This paper focuses upon per capita regional aggregate demands (RAD) for pulp and paper products, where the demand function $RAD_{t,s}$ for region s (s = 1, …, S) at time t is individual demand 'writ large' and can be expressed as

$$(2) \qquad RAD_{s,t} = Z_{s,t}\left(\frac{p_{z_s,t}}{p_{x_s,t}}, \frac{I_{s,t}}{p_{x_s,t}}; \varphi_s(se_{s,t}, w_{s,t})\right) = Z_{s,t}(p^r_{z_s,t}, I^r_{s,t}; \varphi_s(se_{s,t}, w_{s,t}))$$

$p^r_{z_s,t}$ is the real (i.e. relative) price of pulp and paper products at time t and $I^r_{s,t}$ is real per capita aggregate income at time t. Conditioning regional demands are an area's preferences, as reflected by socio-economic characteristics $se_{s,t}$ and other exogenous demand-shifting factors $w_{s,t}$. Equation (2) motivates empirical models aimed at characterizing aggregate per capita demands for pulp and paper products.

2.1 General Demand Model

As will be discussed in Section 3, data for this analysis is a panel of four regions over a 40 year period. Having a time series of cross sections enables one to estimate fixed effects models, an advantage of which is the development of parsimonious specifications where the region's fixed effects parameter summarizes the net effect of cross-section heterogeneity due to excluded variables.[4]

From equation (2), a general fixed effects specification for region s (s = 1, … , S) at time t (t = 1, … , T) can be expressed as

$$(3) \qquad RAD_{s,t} = \alpha_s + \beta_p p^r_{z_s,t} + \beta_I I^r_{s,t} + \beta_{k_s} se_{k_s,t} + \beta_{k_w} w_{k_w,t} + \beta_t \, year + \varepsilon_{s,t}$$

which assumes that marginal price and income effects vary by region and the variable 'year' is a time trend intended to capture changes in information technology as well as other temporal demand shifters that occurred during the forty year period.

2.2 Engle Function Model

A parsimonious specification of (3) is an Engel function that relates per capita pulp and paper products consumption to income per capita,

$$(4) \qquad RAD_{s,t} = \alpha^*_{s,t} + \beta_t \, year + \beta_I I^r_{s,t} + \varepsilon_{s,t} \qquad\qquad s = 1, \ldots, S$$

where $\alpha^*_{s,t} = \alpha_s + \beta_p p^r_{z_s,t} + \sum_{k_s} \beta_{k_s} se_{k_s,t} + \sum_{k_w} \beta_{k_w} w_{k_w,t}$, which is a function of time through its dependence upon price, socioeconomic characteristics, and other contemporaneous demand determinants. Assuming that the time trend 'year' captures time-related changes during the sample period, the net effect of excluded determinants is independent of time, that is, $\alpha^*_{s,t} = \alpha^*_s$ and equation (4) becomes

$$(5) \qquad RAD_{s,t} = \alpha^*_s + \beta_t \, year + \beta_I I^r_{s,t} + \varepsilon_{s,t} \qquad\qquad (s = 1, \ldots, S)$$

a specification that highlights the advantages and restrictions associated with fixed effects models. Equation (5) focuses on the relationship between demand and real income to the exclusion of other demand determinants. In a panel of observations, the fixed effects parameter for each region captures cross section heterogeneity by accounting for effects which vary over cross sections but are constant over

[4] Fixed effects models are also referred to as dummy variable regression models in which dummy variables are defined for S – 1 cross sections, where S is the total number of cross sections and the constant term represents the omitted cross section.

the time period. In that some subset of excluded variables is likely to be correlated with income, the specification in equation (5) also reflects a non-zero correlation between α_s^* and $I_{s,t}^r$, which argues in favor of a fixed effects rather than a random effects specification.[5] However, in capturing the common effects of temporal changes throughout the sample period, a time trend reduces the correlation between α_s^* and $I_{s,t}^r$, suggesting that α_s^* will appropriately capture cross section heterogeneity and that the more parsimonious Engel specification will provide unbiased estimates of the impact that changes in real income have upon consumption behavior.[6]

2. Data

3.1 Definition of Regions

This analysis focuses on four regions of the world – Asia[7], Europe[8], North America Free Trade Area (NAFTA)[9], and South America[10]. Although not a census of all consuming countries, in 2000 the

[5] The Pearson correlation between GDP per capita and year is .30 and the correlation between GDP per capita and the fixed effect for NAFTA, Europe, and Asia is .75, .24, and -.63 respectively.

[6] An alternative empirical model is a dynamic model which would include a lagged dependent variable as an explanatory variable. Theoretically, since pulp and paper are products are nondurable, an argument for including a lagged dependent variable in the estimating equation is habit persistence. Except for household/sanitary and writing/printing sectors of the industry, habit persistence is less likely to apply. Specifying first order differences in the dependent and independent variables, a general methods of moments instrumental variable estimator can be used where the second or third order lag for the dependent variable is the instrumental variable for the first order difference in the dependent variable. As noted in Greene (2000, pp. 582-3), the estimator is inefficient.

[7] There are forty-seven countries included in Asia: Armenia (since 1992), Afghanistan, Azerbaijan. Republic of (since 1992),Bahrain, Bangladesh, Bhutan, Brunei Darussalam, China, Myanmar, Sri Lanka, Cyprus, Georgia(since 1992), India, Indonesia, Iran. Islamic Rep of, Iraq, Israel, Kazakhstan(since 1992), Japan, Jordan, Kyrgyzstan (since 1992), Cambodia, Korea. Democratic People's Republic, Korea. Republic of, Kuwait, Laos, Lebanon, Malaysia, Maldives, Mongolia, Nepal, Pakistan, Philippines, Timor-Leste, Qatar, Saudi Arabia, Singapore, Tajikistan(since 1992), Syrian Arab Republic, Turkmenistan(since 1992), Thailand, Oman, Turkey, United Arab Emirates, Uzbekistan(since 1992), Viet Nam, and Yemen.

[8] Europe includes forty-three countries: Albania, Andorra, Austria, Belgium, Luxembourg, Bulgaria, Czechoslovakia(ended at 1992), Denmark, Belarus(since 1992), Estonia(since 1992), Faeroe Islands, Finland, France, Germany, Bosnia and Herzegovina(since 1992), Gibraltar, Greece, Hungary, Croatia(since 1992), Iceland, Ireland, Italy, Latvia(since 1992), Lithuania(since 1992), Malta, Moldova. Republic of(since 1992), Netherlands, Macedonia. The Former Yugoslavia Republic(since 1992), Norway, Czech Republic(since 1993), Poland, Portugal, Romania, Russian Federation(since 1992), Serbia and Montenegro(since 1992), Slovenia(since 1992), Slovakia(since 1993), Spain, Sweden, Switzerland, United Kingdom, Ukraine(since 1992), Yugoslavia SFR(ended at 1991).

[9] NAFTA includes three countries: Canada, Mexico, and the United States. Canada and the United States are the main countries, since Mexico has very little influence in the demand for NAFTA paper and paperboard products, representing less than 4% of the whole NAFTA region.

[10] South America includes 14 countries: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Falkland Islands (Malvinas), French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela. Bolivian Republic of.

combined share of the four regions exceeds well over 90% of world paper/paperboard production and demand and nearly 100% of pulp demand.[11]

3.2 Definition of Product Categories

Consistent with United Nations Food and Agriculture Organization (FAO) definition, the pulp, paper and paperboard products for this analysis fall into two broad categories: 1) paper/paperboard[12], which include newsprint, printing and writing paper[13], household and sanitary paper[14], and wrapping/packaging paper and paperboard[15]; and 2) pulp, which includes chemical wood pulp, mechanical wood pulp, semi-chemical wood pulp, dissolving wood pulp, recovered fiber pulp, and other fiber pulp. In addition, we use "total" to denote the sum of paper/paperboard and pulp products.

3.3 Data Source and Description

Our analysis focuses on pulp and paper demands among four regions over a forty year period, 1961 – 2000. Similar to other studies (e.g. Buongiorno (1978), Baudin and Lundberg (1987), and Bolkesjø, Obersteiner and Solberg (2003)), the demand for pulp and paper is apparent demand, defined as the production plus imports minus exports.[16] For the period 1961-2000, the FAO provided annual data for countries in each of the four regions. Summing apparent demands for all countries in a region generated regional apparent demands per year and dividing by regional population gives regional apparent demand per capita.

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[11] The percentages are computed according to FAO data, but for wrapping /packaging paper/board category, we made corrections for the world and North America Free Trade Area region. The production data for United States in year 1994 and 1995, in comparison with 1991, 1992, 1993, 1996, and 1997 were off by an order of magnitude (e.g. 4.2 million in 1994 versus 39.8 million in 1993 and 47.4 million in 1996) Based upon the production in the years immediately before and after 1994 and 1995, we corrected the data to reflect the trend between 1991 and 1997.

[12] According to FAO, it includes newsprint, printing and writing paper, and other paper and paperboard (including household and sanitary paper, wrapping /packaging paper/board, and other paper & paperboard N.E.S (not elsewhere specified). Here we exclude the subcategory of other paper & paperboard N.E.S.

[13] Included are such papers as bank notes, books and magazines, box lining and covering, bristols, calculator papers, computer paper, duplicating, envelope stock, folder stock, label, lithograph, manifold, offset, onionskin, photographic base paper, poster, stationery, tablet or block, tabulating card stock, typewriter.
Printing and writing paper is composed of following subcategories:

i Coated wood-containing and woodfree printing & writing paper;
ii Uncoated wood-containing and woodfree printing & writing paper.

[14] Household and sanitary paper includes types of creped and uncreped papers such as disposable tissues, facial tissue, napkin, sanitary wadding, toilet tissue towelling, and wiper stock.

[15] This category comprises:

i Unbleached and bleached kraft Liner and other linerboard
ii Semi-chemical and other fluting medium;
iii Sack kraft and other kraft wrapping and packaging;
iv Bleached chemical pulp-based and other pulp-based folding boxboard and recovered paper based folding boxboard.
v Other Wrapping and Packaging N.E.S.

[16] Ideally, apparent demand includes inventory changes but these data were not available.

The Penn World Table provided data on country specific real GDP per capita (1996 dollars) from 1961 to 2000.[17] Multiplying by country population and summing over all countries yielded regional GDP in 1996 dollars for each of the four regions. Dividing by regional population yields real GDP per capita which provides a measure of real income per capita used in the analysis.[18]

Country-specific price data are not available for pulp and paper, in total and by product categories, for the sample period. This analysis uses calculated import prices as a proxy for region-specific prices. First, we calculate regional nominal price using the formula, nominal price = (Nominal Import Value/Import Quantity). Second, regional nominal price is converted to regional real price (in year 2000 dollars) using a regional consumer price index, which is a weighted average of a region's main countries' price indices where a country's weight is its total demand share in the region.[19]

Regional urbanization is defined as the ratio of regional urban population to the corresponding regional total population. FAO provides urban population data used in this analysis.[20]

The unit of observation for the panel data analysis is a region-year and Table 1 reports descriptive statistics for the full data set, disaggregated by region, and disaggregated by product category. The countries associated with the four regions in this study account for 93% to 97% of world consumption, in total and by product categories. Further, although not reported in Table 1, the four regions also account for over 90% of world pulp, paper, and paperboard production, which reflects the definition of apparent demand as production plus net imports. Between regions, however, we see significant differences in apparent demands.

For all regions, per capita demand for pulp, paper, and paperboard products is 154.9 kilograms with a 152.3 kilogram standard deviation. The large variation in apparent demands reflects differences in demand across regions. In the NAFTA region, for example, apparent demand (which primarily reflects US demand) is 395.3 kg per capita, more than twice that in the European region. But consumption in both of these regions is an order of magnitude larger than in Asia or South America, with average per capita demands equal to 23.3 kg and 37.6 kg respectively. In addition, over the sample period, the coefficient of variation (c.v.) in per capita demand is 11.6%, 19.0%, 42.9%, and 30.1% for NAFTA, Europe, Asia, and

[17] Penn World Table is provided by Center for International Comparisons at the University of Pennsylvania (CICUP).

[18] The method to calculate regional real GDP per capita for this study is identical to the procedure that the United Nations uses to generate GDP measures for specified regions.

[19] The price index for Asia includes Japan, India, Indonesia, and South Korean. For Europe, the price index includes France, Italy, UK and Sweden. For NAFTA and South America, respectively, the price index includes US and Canada and Argentina and Brazil.

[20] Criteria that the United Nations FAO use for distinguishing between urban and rural areas include population size, administrative centers of minor civil divisions based on a chosen criterion which may include type of local government, number of inhabitants or proportion of population engaged in agriculture.

South America.[21] In that NAFTA primarily reflects US consumption, which is a mature and stable market, it is not surprising that there is relatively little variation in demand. The higher c.v. for the Europe Union reflects the increase in the number of developing countries that define the Union relative to a narrower definition that only includes the more developed and mature countries. Asia has the highest c.v. and this likely reflects the rising demands for pulp, paper, and paperboard products subsequent to China's market opening in 1992. The c.v. for China is 73%, and the c.v. for India is 35%. Similarly, South American demand has experienced large increases in growth over the past 40 years.

NAFTA accounts for 40.6% of paper and paperboard products, the largest share (54.4% and 14.2 kg per capita) associated with high valued added commodities in the household and sanitary sector and the lowest share (39.4% and 52.6 kg per capita) in the printing and writing sector. Demands in Europe and Asia are the reverse, where household and sanitary products account for the smallest shares (23.4% and 4.5 kg per capita, 15.1% and .6 kg per capita) in the paper and paperboard sectors while print and writing papers account for the largest shares (32.2% and 27.3 kg per capita, 20.1% and 3.7 kg per capita). Interestingly, the largest (4.3% and 1.8 kg per capita) and smallest market shares (2.7% and 5.1 kg per capita) in South America's non-pulp sectors are the same as the NAFTA region.

Consistent with expectations, average per capita GDP throughout the sample period was highest in the NAFTA region, followed by Europe, South America, and Asia. Urbanization rates follow the same pattern, averaging 72.6% for NAFTA, 69.6% for Europe, 67.5% for South America, and 27.8% for Asia.
In contrast to per capita income, growth in per capita demand presents a different picture. Regional demands have different growth rates in the past forty years. The average growth rate of per capita demand is 2.4%, 3.2%, 5.8%, and 5% for NAFTA, Europe, Asia, and South America. But the total demand share of NAFTA has decreased from about 50% to 30%, while the demand share of Asia has increased from about 10% to 30%. The demand share of South America remains flat at about 3%. And the share of Europe fluctuates around 30%. The changes in regional market shares are very similar for pulp and paper/paperboard categories. However, the differences are much greater for the subcategories of household/sanitary paper and wrapping/ packaging paper/board. NAFTA's household/sanitary paper demand share decreased from about 90% to 36%, while both the demand shares of Asia and Europe have increased to about 30%.

There are also differences in the structure of region demands. For newsprint, the net imports are positive and increasing in Asia, while they are negative for NATFA. Imports and exports in Europe, on the other hand, are nearly offsetting. And South American imports are generally larger than South American production. For printing/writing paper, imports and exports are similar in all four regions, while the net

[21] In dividing the standard deviation by the mean, the coefficient of variation is a measure of variation that accommodates comparisons across product categories by adjusting for the scale of units in the variable.

Table 1

Descriptive Statistics

	Total		NAFTA		Europe		Asia		South America	
	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Total										
Apparent Demand per capita (kg)	154.9	152.3	395.3	45.8	163.4	31.1	23.3	10.0	37.6	11.3
Real GDP per capita (1996 US $)	9706.3	6657.8	18313.7	4224.7	12476.1	2380.9	2439.0	925.5	5596.6	997.8
Real price (1996 US $)	3.7	5.6	0.8	0.1	1.3	0.4	1.8	0.7	10.9	7.4
Population (thousands)	934330.1	1036479.0	326599.2	49578.4	528832.7	110172.2	2635451.8	600771.1	246436.8	58942.5
Urbanization Rate (%)	40.26%	3.91%	72.63%	2.52%	69.62%	3.49%	27.75%	5.19%	67.52%	8.22%
% of World Consumption	92.9%	2.5%	42.8%	4.1%	28.0%	1.2%	19.3%	6.1%	2.9%	0.6%
Paper/Paperboard										
Apparent Demand per capita (kg)	77.7	76.2	213.8	30.5	95.2	20.9	14.6	7.1	23.3	6.7
Real GDP per capita (1996 US $)	9706.3	6657.8	18313.7	4224.7	12476.1	2380.9	2439.0	925.5	5596.6	997.8
Real price (1996 US $)	0.2	0.2	0.9	0.1	1.5	0.5	2.0	0.8	12.0	8.1
% of World Consumption	92.9%	2.2%	40.6%	4.6%	28.5%	1.2%	20.7%	6.7%	3.2%	0.5%
Newsprint										
Apparent Demand per capita (kg)	11.8	12.2	34.9	3.1	13.0	2.0	1.8	0.6	3.6	0.4
Real GDP per capita (1996 US $)	9706.3	6657.8	18313.7	4224.7	12476.1	2380.9	2439.0	925.5	5596.6	997.8
Real price (1996 US $)	0.2	0.2	0.8	0.1	1.1	0.4	1.5	0.5	9.3	6.5
% of World Consumption	92.5%	2.0%	44.6%	4.4%	26.6%	2.2%	18.2%	4.9%	3.4%	0.3%
Printing/Writing										
Apparent Demand per capita (kg)	19.9	20.5	52.6	16.1	27.3	9.3	3.7	2.1	5.1	2.2
Real GDP per capita (1996 US $)	9706.3	6657.8	18313.7	4224.7	12476.1	2380.9	2439.0	925.5	5596.6	997.8
Real price (1996 US $)	0.3	0.3	1.1	0.2	1.8	0.6	2.5	0.9	0.7	0.3
% of World Consumption	94.5%	1.5%	39.4%	3.5%	32.2%	1.7%	20.1%	5.5%	2.7%	0.5%
Household and Sanitary										
Apparent Demand per capita (kg)	4.7	5.3	14.2	2.6	4.5	2.3	0.6	0.4	1.8	1.0
Real GDP per capita (1996 US $)	9706.3	6657.8	18313.7	4224.7	12476.1	2380.9	2439.0	925.5	5596.6	997.8
Real price (1996 US $)	0.3	0.4	2.3	1.1	3.0	1.5	4.2	2.3	51.0	37.8
% of World Consumption	97.3%	1.1%	54.4%	13.7%	23.4%	6.6%	15.1%	6.3%	4.3%	1.6%
Wrapping and Packaging										
Apparent Demand per capita (kg)	34.2	36.9	102.0	12.1	35.9	14.2	5.6	3.3	10.1	4.7
Real GDP per capita (1996 US $)	9706.3	6657.8	18313.7	4224.7	12476.1	2380.9	2439.0	925.5	5596.6	997.8
Real price (1996 US $)	0.2	0.3	1.2	0.5	1.3	0.5	1.9	1.0	12.1	8.6
% of World Consumption	96.6%	1.7%	49.8%	13.8%	24.5%	8.5%	19.0%	7.0%	3.3%	1.2%
Pulp										
Apparent Demand per capita (kg)	60.3	64.7	181.5	17.6	68.1	10.7	8.8	3.0	14.4	4.7
Real GDP per capita (1996 US $)	9706.3	6657.8	18313.7	4224.7	12476.1	2380.9	2439.0	925.5	5596.6	997.8
Real price (1996 US $)	0.2	0.2	0.7	0.2	1.1	0.4	1.5	0.5	8.6	6.1
% of World Consumption	93.0%	2.9%	45.7%	3.2%	27.4%	1.5%	17.3%	5.1%	2.7%	0.8%

import is positive in Asia and negative in Europe. For household and sanitary paper, imports and exports are again close in the four regions. For the wrapping/packaging sector, Europe and NAFTA are net exporters, while Asia and South America are net importers.

We also see in Figures 1 – 3 that, as expected, there is a positive relationship between per capita GDP and per capita demand for total pulp and paper/paperboard and pulp.[22] However, in the NAFTA region the per capita demand for total pulp and paper flattens out (at around 450 kg per capita) once per capita GDP reaches $25,000 US. This may be evidence of a saturation level which, if so, raises the question of how the saturation level varies for the different categories of pulp and paper.

Demand growth has also varied throughout the forty years, especially during the past two decades (Appendix 1). Virtually all sectors in all regions exhibited high growth rates in the 1960s, averaging from a low of 38.9% for newsprint to a high of 366.1% for the Household/Sanitary sector. During the seventies, growth rates fell in all sectors. For example, Newsprint growth slowed, with an overall 7.3% average growth rate. Growth in the Household/Sanitary sector also slowed to 59.4% average growth in 1970, with NAFTA experiencing the largest drop from 50% in the 1960s to 3.2% in the 1970s. Newsprint growth continued to slow in the 1980s for all but the Asian region. And in the 1990s, Newsprint growth in the NAFTA and European regions was negative (-5.6% and -1.5% respectively). In addition to Newsprint, Europe experienced decreased growth rates in the Pulp sector (-6.3%), Paper & Paperboard sector (-4.4%), Printing and Writing sector (-2.4%), and Wrapping/Packaging sector (-0.3%).

4. Estimation Results

4.1 Engle Functions

Table 2 reports Engel function estimation results for total pulp, paper, and paperboard and for specific product categories in the pulp and paper industry. In all of the reported models, standard errors are heteroskedastic-robust and the models are corrected for first order and, in some cases second order, serial correlation. Also, preliminary analyses found that double-log models yielded the best fits.

Column (a) in Table 2 reports the results for total pulp and paper for the four regions. The fixed effects coefficients indicate that, relative to the South American region, per capita demand for pulp and paper is higher in each of the other regions. All else constant, consumers in NAFTA, European Union, and Asia have per capita demands that are 11.3%, 6.64%, and 4.52% higher relative to those in South America. We also see in Column (a) that GDP per capita has a strong effect upon per capita demand.

Each of the GDP-related variables is statistically significant at a .01 level. Importantly, there are

[22] In 1992, due to the addition of several countries from former USSR, Europe experienced a drop in demand for paper and paperboard. Thus the population increased greatly while the demand didn't change at the same rate.

	Total (a)		Pulp (b)		Paper/Paperboard (c)		Newsprint (d)		Printing/ Writing (e)		Household/ Sanitary (f)		Wrapping/ Packaging (g)	
Variable	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Fixed Effects														
Constant	-9.90	-10.40 #	-10.83	-7.74 #	-9.05	-10.47 #	1.07	0.86	-10.35	-7.30 #	-23.07	-6.51 #	-22.79	-11.26 #
Asia	4.60	5.66 #	6.93	5.63 #	2.44	3.62 #	-6.50	-6.23 #	3.22	2.92 #	9.61	3.37 #	13.94	8.21 #
Europe	6.76	7.54 #	9.70	7.04 #	4.58	6.41 #	-3.91	-3.50 #	3.63	3.11 #	-6.02	-2.01 +	10.10	4.82 #
NAFTA	11.36	12.09 #	13.37	8.89 #	9.87	13.64 #	1.53	1.35	8.52	7.25 #	27.02	8.09 #	26.82	14.68 #
GDP Related														
log (GDP per capita)	1.56	13.59 #	1.55	9.16 #	1.40	13.57 #	0.02	0.11	1.35	7.93 #	2.67	6.29 #	2.85	11.59 #
log (GDP per capita) * Asia	-0.49	-5.17 #	-0.79	-5.49 #	-0.23	-2.93 #	0.75	6.26 #	-0.32	-2.50 +	-1.07	-3.27 #	-1.55	-7.96 #
log (GDP per capita) * Europe	-0.69	-6.92 #	-0.99	-6.46 #	-0.45	-5.65 #	0.55	4.42 #	-0.32	-2.43 +	0.51	1.50	-1.17	-5.04 #
log (GDP per capita) * NAFTA	-1.11	-10.70 #	-1.29	-7.82 #	-0.95	-11.82 #	0.07	0.58	-0.79	-6.07 #	-2.84	-7.75 #	-2.83	-13.98 #
Other Variables														
log(t)	0.020	0.82	0.0400	1.36	0.003	2.11 +	0.020	0.85	0.01	5.73	0.02	2.94	0.13	2.88
AR, Lag 1	-0.58	-8.82	-0.68	-11.33	-0.47	-6.52	-0.61	-7.50	-0.54	-6.66	-0.89	-10.96	-0.46	-6.27
AR, Lag 2							0.14	1.70	0.08	1.00	0.17	2.06		
DW =	2.03		2.03		2.00		1.90		1.83		1.84		1.93	
Pr > DW=	0.6263		0.6093		0.7005		0.8646		0.9479		0.9212		0.8289	
df =	150		150		150		149		149		149		147	
Root MSE	0.0446		0.05853		0.04192		0.0645		0.06839		0.11555		0.10756	
R^2=	0.9937		0.9860		0.9960		0.9905		0.9971		0.9533		0.9812	

Notes: (f) and (g) use log(t) instead of t for the time trend. Excepting Wrapping Packaging, there were 160 observations for each model. Demand data for Europe was missing in Wrapping/Packaging sector for 1961-1963.

* Significant at .05 level, 2 tail test

* Significant at .01 level, 2 tail test

differential effects across the four regions. The estimated coefficients are point estimates for the income elasticities and we see that, all else constant, the demand for pulp and paper is income elastic in South America, approximately unitary elastic in Asia, and income inelastic in the more developed NAFTA and European Union regions. A 1% increase in GDP per capita increases per capita demand for pulp and paper by 1.54%, 1.06%, 0.86%, and 0.44% in South America, Asia, European Union, and NAFTA.

Table 3 reports the regional elasticity estimates for each of the models in Table 2. Although the elasticity pattern for the separate product categories is similar to that for total pulp and paper, there are a number of interesting differences. The elasticities for paper and paperboard, which excludes pulp, are similar to those for total pulp and paper category, which is not unexpected given the pulp elasticities reported in Column (b). Newsprint on the other hand is income inelastic for each of the regions but much more so for the NAFTA and South American regions. The low value for the NAFTA region is consistent with Hetemaki and Nilson (2005) on the increased role of information technology in delivering news content. During the 20 year period 1980 – 2000, per capita income in constant 1996 dollars approximately doubled in South America ($3722 US in 1980 to $6985 US dollars in 2000) and Asia ($2171 US in 1980 to $4363 US in 2000), generating a 122% and 118% in paper and paperboard consumption.

Table 3

GDP Elasticities - Engle Function Model

Region	Total (a)	Pulp (b)	Paper/ Paperboard (c)	Newsprint (d)	Printing/ Writing (e)	Household/ Sanitary (f)	Wrapping/ Packaging (g)
NAFTA	0.45	0.26	0.45	0.09	0.56	-0.17	0.02
Europe	0.87	0.56	0.95	0.57	1.03	3.18	1.68
Asia	1.07	0.76	1.17	0.77	1.03	1.60	1.30
South America	1.56	1.55	1.40	0.02	1.35	2.67	2.85

Apparent demand for printing and writing papers moves proportionately with income for Asia and Europe but is income elastic for South America (1.36 elasticity) and income inelastic for NAFTA (0.56). The strongest results occur in the Household/Sanitary and Wrapping/Packaging Sectors of the industry. For the European Union, Asia, and South America, a 1% increase in GDP per capita increases the apparent demand for household and sanitary paper products by 2.62 %, 1.53%, and 2.62% respectively, indicating that consumer demands for products in these sectors are income sensitive. For the NAFTA region, however, these products are inferior goods, with demands decreasing by 0.24% for a 1% increase in GDP per capita, suggesting a saturation point.

Wrapping and packaging demand exhibits a similar pattern, although generally less in magnitude, to the household/sanitary sector. NAFTA's small positive response to an increase in GDP per capita may reflect the

transfer of packaging activities to Asia, Europe, and South America that are associated with the offshoring and outsourcing of many NAFTA (particularly US manufacturing activities). Consistent with this interpretation, a 1% increase in per capita GDP increases consumption in the European Union, Asia, and South America by 1.68%, 1.30%, and 2.85% respectively.

4.2 Demand Functions

To explore the robustness of the Engle function results and to analyze the impact that other exogenous variables have upon per capita pulp and paper demands, we estimate demand functions that include price and regional urbanization as well as GDP per capita.[23] To avoid endogeneity problems, we use last year's price as an instrument for current price. In addition, preliminary estimations found that linear- log models fit best for the Printing/Writing and Household/Sanitary sectors.

Reflecting higher levels of education and literacy rates in urban populations and a larger set of final products that embody more value-added stages of production in urban areas, the models reported in Table 4 include Urbanization as an exogenous variable. With respect to GDP per capita, we see that the coefficient estimates in Table 4, and summary estimates in Table 5, are generally similar to those reported in Tables 2 and 3 but there are a number of differences.

Overall, the point estimates in Table 5 for paper/paperboard are most consistent with those in Table 2. But the estimates for Asia and South America are uniformly smaller in the richer model. This is particularly true for Asia in the Printing/Writing, Household/Sanitary, and Wrapping/Packaging sectors. And, with the noted exception of the Household/Sanitary sector, income elasticities are larger for Europe relative to the Engel specification of the model.

Demand is least income elastic in the NAFTA region across all sectors, a result that is qualitatively consistent with Table 3, but quantitatively more elastic than the Engel function estimates. Further, the NAFTA estimate for Wrapping/Packaging is more income sensitive and the income elasticity demand in the Household/Sanitary fell from -0.17 to -0.61, raising the question of whether there are saturation points in sectors of the industry.

With respect to the price variable, the results indicate that pulp and paper demands, in total and across industry sectors, are price insensitive. With the exception of the Household/Sanitary and Wrapping/Packaging sectors where price was positive but not significant, the point estimates are in a narrow range, -0.08 to -0.05. Although consistent with the literature, we view these results as tentative given the absence of better price data at the regional level.

[23] Depending on the sector, we adjusted for first and second order serial correlation. Preliminary analyses generally rejected the hypothesis that the coefficients for price and urbanization differed across regions.

Pulp and Paper Demand Functions

	Total (a)		Pulp (b)		Paper / Paperboard (c)		Newsprint (d)		Printing/ Writing (e)		Household/ Sanitary† (f)		Wrapping/ Packaging† (g)	
Variable	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
Fixed Effects														
Constant	-6.7	-4.55 #	-6.21	-2.79 #	-7.64	-5.92 #	-8.15	-3.48 #	-8.42	-3.28 #	-8.74	-1.67 *	-18.65	-5.17 #
Asia	4.73	6.14 #	8.18	6.63 #	2.42	3.7 #	-5.81	-4.48 #	8.97	5.45 #	7.93	2.88 #	17.25	9.01 #
Europe	2.67	2.12 +	2.99	1.53	2.34	2.16 +	0.36	0.18	0.78	0.38	-7.04	-1.98 *	2.69	0.81
NAFTA	6.02	3.97 #	4.73	1.99 +	6.65	5.11 #	6.35	2.55 +	2.95	1.37	15.95	3.83 #	17.75	4.84 #
														\
GDP Related														
ln (GDP per capita)	1.27	7.95 #	1.16	4.81 #	1.29	9.17 #	1.03	4.07 #	1.26	4.37 #	1.03	1.76 *	2.54	6.51 #
ln (GDP per capita) * Asia	-0.44	-5.10 #	-0.79	-5.80 #	-0.19	-2.65 #	0.56	3.91 #	-0.81	-4.30 #	-0.8	-2.57 #	-1.73	-8.21 #
ln (GDP per capita) * Europe	-0.25	-1.75 *	-0.26	-1.21	-0.22	-1.77 *	0.004	0.02	-0.007	-0.03	0.75	1.83 *	-0.36	-0.97
ln (GDP per capita) * NAFTA	-0.55	-3.29 #	-0.39	-1.50	-0.62	-4.34 #	-0.54	-2.00 +	-0.22	-0.91	-1.64	-3.26 #	-1.88	-4.64 #
Price Related														
ln (Real $Price_{-1}$)	-0.07	-3.86 #	-0.07	-3.33 #	-0.05	-3.32 #	-0.08	-2.97 #	-0.08	-2.11 +	0.002	0.07	0.03	0.99
Other Variables														
log(Urbanization)	0.95	2.93 #	1.81	3.61 #	0.45	1.59	-1.74	-3.29 #	2.13	5.10 #	2.12	2.45 +	2.38	2.96 +
log(t)	-0.008	-3.25 #	-0.01	-3.83 #	-0.003	-1.26 *	-0.0009	-0.24	-0.03	-0.63	0.37	4.42 #	-0.01	-1.83 *
AR, Lag 1	-0.49	-6.79 #	-0.61	-9.91 #	-0.40	-5.22 #	-0.6	-8.88 #	-0.53	-7.51 #	-0.81	-9.50 #	-0.46	-6.15 #
AR, Lag 2											0.24	2.81 #		
DW =	1.99		1.95		1.97		1.90		1.80		1.94		1.87	
Pr > DW=	0.7745		0.8225		0.8167		0.8999		0.9737		0.8162		0.9377	
df =	144		144		144		144		144		129		142	
Root MSE	0.04153		0.0554		0.04023		0.05894		0.06661		0.10967		0.10627	
R^2=	0.9960		0.9898		0.9970		0.9871		0.9889		0.9737		0.9804	

Notes: (f) and (g) use log(t) instead of t for the time trend. Excepting the Household/Sanitary and Wrapping Packaging sectors, there were 156 observations. Four obserations were lost due to the lag of the pricevariable. In addition, in the Household/Sanitary sector, NAFTA and South American prices were not available for seven periods (1962-1968, 1986-1992 respectively). For Wrapping/Packaging sector, demand data for Euope was not available for 1962-1963.

* Significant at .10 level, 2 tail test

* Significant at .05 level, 2 tail test

* Significant at .01 level, 2 tail test

Table 5

Elasticities - Demand Function Models

Region	Total (a)	Pulp (b)	Paper/ Paperboard (c)	Newsprint (d)	Printing/ Writing (e)	Household/ Sanitary (f)	Wrapping/ Packaging (g)
GDP Related							
NAFTA	0.72	0.77	0.67	0.49	1.04	-0.61	0.66
Europe	1.02	1.16*	1.07	1.03*	1.26*	0.28	2.18
Asia	0.83	0.37	1.10	0.47	0.45	0.23	0.81
South America	1.27	1.16	1.29	1.03	1.26	1.03	2.54
Price	-0.07	-0.07	-0.05	-0.08	-0.08	**	**
Urbanization	0.95	1.81	**	-1.74	2.13	2.12	2.38

* Interaction variable not significantly different from 0
** Variable insignificant

Last, the results in Table 4 indicate that Urbanization is an important determinant of per capita pulp and paper demands. Only for the Paper/Paperboard sector is there an absence of an effect.[24] For the Printing/Writing, Household/Sanitary, and Wrapping/Packaging sectors, there is a strong elastic relationship between urbanization and per capita demands, with a 1% increase in urbanization leading to over a 2% increase in demands. Also of interest is the finding that urbanization and newsprint demands are negatively related. All else constant, a 1% increase in urbanization reduces per capita demands 1.74%, indicating that urban areas offer residents viable news and advertising substitutes for newspapers.

5. Forecasting Future Demands for Pulp and Paper

To explore the implications for future demands, the models reported in Table 4 were used to forecast in-sample and out-of-sample per capita demands. In order to generate the predictions, we assume that real GDP per capita and urbanization rates follow a second order autoregressive linear trend, based upon the past 10 years, and that the real price follows a random walk with no trend.[25] The predicted values of the independent variables and the estimated coefficients from the models reported in Table 4 were used to generate the in-sample and out-of-sample forecasts and their associated 95% confidence intervals.

[24] The coefficient value was 0.45 and insignificant at a .10 level, although significant at a .15 level.
[25] GDP per Capita and Urbanization exhibited positive trends during the 1990-2000 period. Also, in preliminary work, forecasting real prices based upon a linear trend for the past 10 years generated some negative values for predicted price (lagged one year) during the forecast period. To avoid this, we adopted the mean real price (lagged one year) that prevailed during the 1990-2000 period. Consistent with this, there was some negative trending in NAFTA prices during the early part of the 1990s but little trending in any price series after 1995.

In order to get a sense of how forecast uncertainty and how this compares across regions and product categories, consider a normalized confidence interval, NCI, defined as the difference between category i's upper and lower bound of its 95% confidence interval divided by the predicted demand for product category i, $\frac{95\%\,\text{Upper Limit}_i - 95\%\,\text{Lower Limit}_i}{\text{Demand per Capita}_{\text{Predicted,i}}}$. NCI ranges from an upper limit that approaches $+\infty$ when there is large uncertainty (wide 95% confidence interval) to a lower limit that approaches 0 with greater predicted demand certainty (narrow 95% confidence interval). For each region-category, Table 6 reports the NCIs and Appendix I Figures 1-28 depict the actual and forecast series.

Table 6
Normalized Confidence Interval Range

Product Category
In-Sample

Region	Total	Pulp	Paper/ Paperboard	Newsprint	Printing/ Writing	Household/ Sanitary	Wrapping/ Packaging
Asia	0.18	0.26	0.17	0.27	0.30	0.51	0.46
Europe	0.18	0.26	0.17	0.27	0.29	0.50	0.47
NAFTA	0.18	0.25	0.17	0.26	0.29	0.50	0.46
South America	0.19	0.26	0.18	0.27	0.30	0.53	0.47

Out-of-Sample*

Region	Total	Pulp	Paper/ Paperboard	Newsprint	Printing/ Writing	Household/ Sanitary	Wrapping/ Packaging
Asia	0.22	0.33	0.20	0.35	0.37	0.72	0.55
Europe	0.24	0.36	0.22	0.38	0.33	0.63	0.59
NAFTA	0.22	0.33	0.20	0.34	0.37	0.72	0.55
South America	0.22	0.33	0.20	0.34	0.36	0.69	0.55

* Shaded areas reflect highest percentage increases in NCI.

From Table 6 and the figures, one first notices form the In-Sample results that there is little cross regional differences in the NCIs. This is not the case, however, across product categories. Not surprisingly, predictions in the aggregate categories – Total and Paper/Paperboard – are more certain than in the disaggregate groupings – Pulp, Newsprint, Printing/Writing, Household/Sanitary, and Wrapping/Packaging. In addition, the least certain In-Sample predictions are in the Household/Sanitary and Wrapping/Packaging groups.

From the Out-of-Sample results, the NCIs are uniformly higher than those for the In-Sample observations, which reflects the downward bias in forecasting error when using an estimated model to

forecast those observations used to estimate the model. And similar to In-Sample NCIs, Out-of-Sample NCIs continue to exhibit little cross region heterogeneity, although greater than for the In-Sample NCIs. However, when looking at percentage changes from In-Sample to Out-of-Sample NCIs, there are some interesting differences, which are identified by the shaded areas. In particular, the Out-of-Sample NCIs for Europe experienced the largest percentage increases for all but the Printing/Writing and Household/Sanitary sectors, ranging from 24% for Paper/Paperboard to 39.8% for Pulp, and reflecting greater forecast uncertainty for Europe than is the case for the other regions. For the Printing/Writing and Household/Sanitary sectors, on the other hand, the Out-of-Sample NCIs for Asia and NAFTA exhibited the largest percentage increases, over 25% and 40% increases, respectively, signaling greater forecasting uncertainty in comparison with the other regions. Overall, the results presented in Table 6 and Figures 1-28 indicate that that the estimated demand functions have differential forecasting properties, which argues for the need to better understand the regional dynamics in particular region-categories in order to develop improved demand models.

6. Conclusion

The global pulp and paper industry is experiencing significant structural change on both the demand and supply sides of the market. Increasing development and per capita incomes in Asia, particularly China and India, substantial pulp and paper capacity investments in Asia and South America, and the increasing levels of international trade have had far reaching effects on the US pulp and paper industry, substantially reducing market shares across all product categories. Focusing upon four major regions of the world – NAFTA, South America, Europe, and Asia – which represent over 95% of world consumption and a forty year period, this analysis develops and estimates regional per capita demand models for each region and across two aggregate categories – Total, Paper/Paperboard – and five specific sectors – Pulp, Newsprint, Printing/Writing, Sanitary/Household, and Wrapping/Packing.

The Engle and demand function results indicate that NAFTA product sectors, with the possible exception of Printing/Writing, are income inelastic and generally, although not uniformly, more inelastic than found in the other three regions. The Paper/Paperboard sector in both cases provided similar results qualitatively and in the magnitude of their coefficients. And, for the NAFTA region, the income elasticity in the Household/Sanitary sector was negative in both specifications, suggesting that this sector, dominated by US consumption, exhibits characteristics of an inferior good. Also consistent across specifications is the result that for all product categories, excepting Newsprint and possibly Household/Sanitary, per capita demand in South America is income elastic with the Printing/Writing Sectors being most sensitive to income increases.

The results also highlighted differences across specifications, particularly for Asia and Europe. This is most evident in the Household/Sanitary sector where the income elasticity estimates equaled 3.18 and 1.60 for Europe and Asia, respectively, in the Engle model and 0.28 and 0.23 in the demand specification.

Consistent with other studies, per capita demands were price inelastic within a narrow range, -0.08 to -0.05. For the Household/Sanitary and Wrapping/Packaging sectors, the price variable was not statistically significant. And, as expected, the extent to which a region's populace is urbanized generally affects its demands for pulp and paper products. With the of Newsprint (and possibly the Paper/Paperboard sector whose estimated coefficient is 0.45 and significant at the 0.15 level), a 1% increase in urbanization produces a 1.8% increase in pulp demand per capita and over a 2% increase in Printing/Writing, Household/Sanitary, and Wrapping/Packaging sectors. And importantly, a 1% increase in urbanization reduces newsprint demands per capita, suggesting that the information technology advances are impacting consumer demands for newspapers and related products. And based upon a forecasting analysis using estimates from the demand function,

Focusing upon worldwide regional demands provides important insights into the shifting regional demands. The Engle function results presented in Table 4 provide a pattern of income elasticities for all but the Household/Sanitary and Wrapping/Packaging sectors that were broadly consistent with more mature regions of the world having less elastic demands. This pattern was generally absent in the demand specification results. Although there appear to be high quality data for developing regional GDP estimates, the same is less true for price data. An area for future research is to develop better price measures or other price instruments for the region-product categories to validate the findings of this analysis. Related to this, the Household/Sanitary sector differed significantly between the two models and which suggests that better price measures and richer model specifications are required for this consumer products oriented sector of the industry.

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Demand per Capita vs GDP per Capita - Total

1960 - 2000

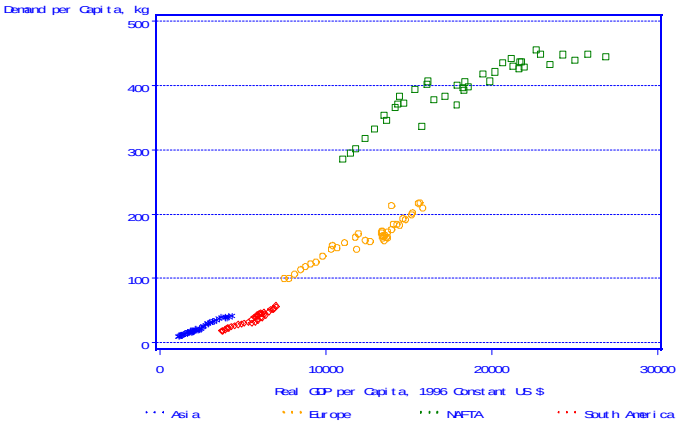


Figure 1

Demand per Capita vs GDP per Capita - Pulp

1960 - 2000

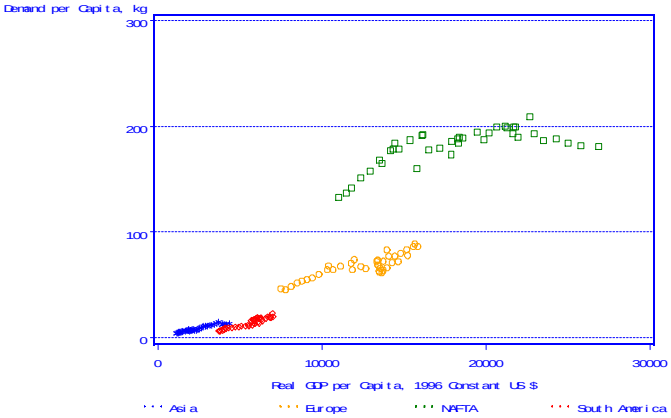


Figure 2

Demand per Capita vs GDP per Capita - Paper/Paperboard

1960 - 2000

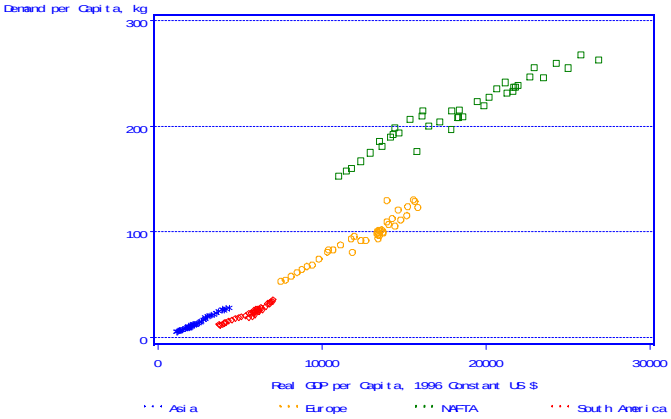


Figure 3

Appendix 1

Regional and World Growth Rates by Decade-Sector

	Sector	World		Sector		Sector		Sector	
1960s	**Total**	49.1	**1960s**	**Ppr&Pprbrd**	48.1	**1960s**	**Prnt/Wrtg**	46.1	**1960s**	**Wrp/Pkg**	191.1
NAFTA	29.7		NAFTA	25.6		NAFTA	35.3		NAFTA	20.6	
Europe	51.4		Europe	55.9		Europe	77.8		Europe	385.3	
Asia	64.4		Asia	65.9		Asia	47.1		Asia	107.2	
South America	50.9		South America	45.1		South America	24.2		South America	251.3	
1970s		24.4	**1970s**		26.3	**1970s**		42.5	**1970s**		39.4
NAFTA	6.5		NAFTA	7.5		NAFTA	30.6		NAFTA	4.4	
Europe	17.3		Europe	19.9		Europe	38.2		Europe	23.7	
Asia	27.4		Asia	38.1		Asia	51.4		Asia	29.3	
South America	46.2		South America	39.7		South America	50.0		South America	100.0	
1980s		26.3	**1980s**		28.3	**1980s**		51.2	**1980s**		39.6
NAFTA	9.6		NAFTA	13.3		NAFTA	37.4		NAFTA	8.6	
Europe	26.6		Europe	32.0		Europe	53.0		Europe	26.4	
Asia	60.6		Asia	62.9		Asia	109.4		Asia	106.3	
South America	8.5		South America	4.9		South America	5.2		South America	16.9	
1990s		13.7	**1990s**		18.5	**1990s**		38.6	**1990s**		22.5
NAFTA	3.3		NAFTA	13.8		NAFTA	17.8		NAFTA	18.9	
Europe	-5.2		Europe	-4.4		Europe	-2.4		Europe	-0.3	
Asia	27.4		Asia	35.2		Asia	24.9		Asia	64.2	
South America	29.1		South America	29.3		South America	113.9		South America	7.4	
1960s	**Pulp**	51.4	**1960s**	**Newsprint**	38.9	**1960s**	**Hh/Sanitary**	366.1			
NAFTA	34.5		NAFTA	19.2		NAFTA	50.0				
Europe	46.2		Europe	31.5		Europe	1133.8				
Asia	62.6		Asia	65.9		Asia	124.2				
South America	62.4		South America	9.1		South America	156.4				
1970s		22.7	**1970s**		7.3	**1970s**		59.4			
NAFTA	5.5		NAFTA	4.8		NAFTA	3.2				
Europe	14.1		Europe	8.2		Europe	54.9				
Asia	13.3		Asia	15.3		Asia	48.0				
South America	58.1		South America	1.1		South America	131.5				
1980s		23.9	**1980s**		6.9	**1980s**		51.8			
NAFTA	5.5		NAFTA	1.4		NAFTA	19.2				
Europe	19.3		Europe	27.9		Europe	40.5				
Asia	56.8		Asia	23.0		Asia	119.6				
South America	14.2		South America	-24.6		South America	28.1				
1990s		6.8	**1990s**		6.9	**1990s**		18.9			
NAFTA	-8.8		NAFTA	-5.6		NAFTA	13.0				
Europe	-6.3		Europe	-1.5		Europe	3.1				
Asia	13.7		Asia	27.1		Asia	38.8				
South America	28.7		South America	7.7		South America	20.7				

Appendix II

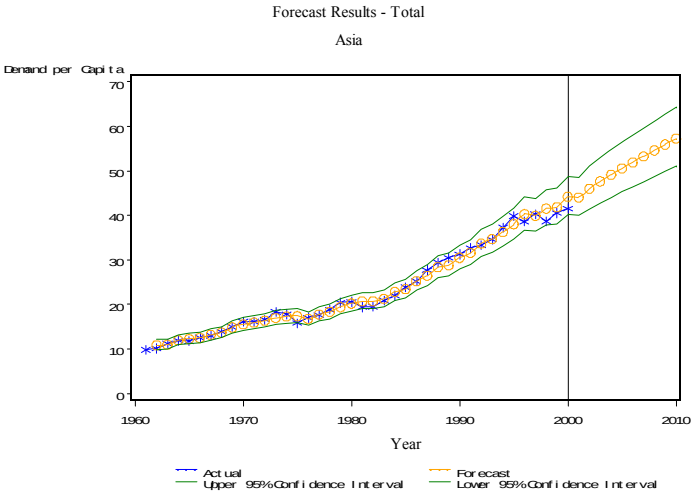


Figure 1

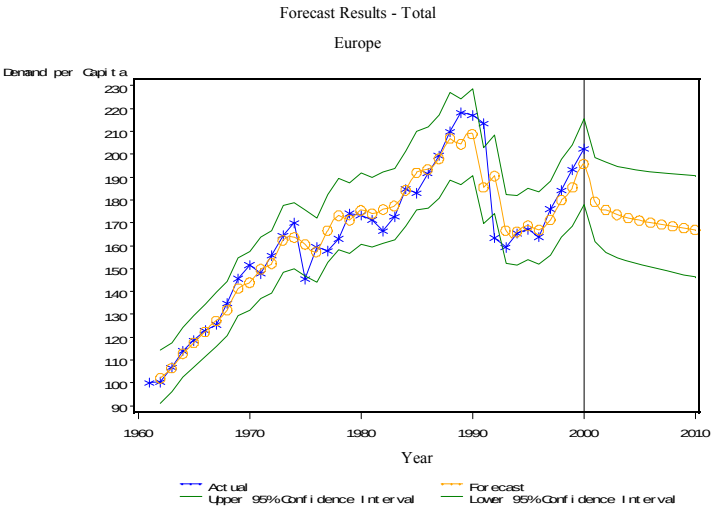
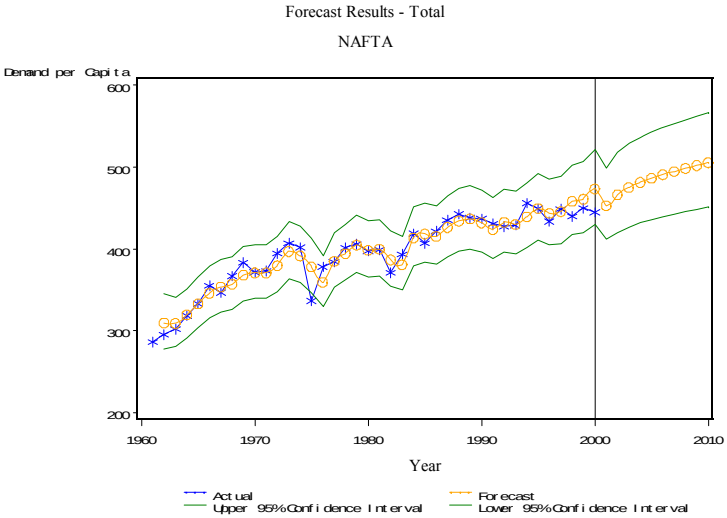


Figure 2



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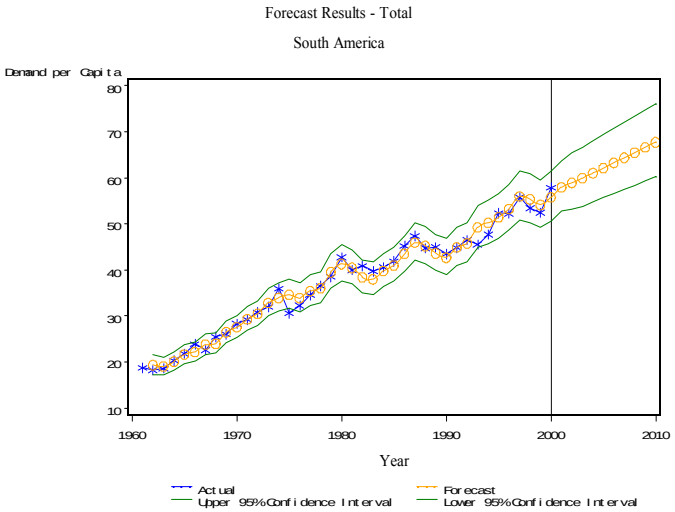

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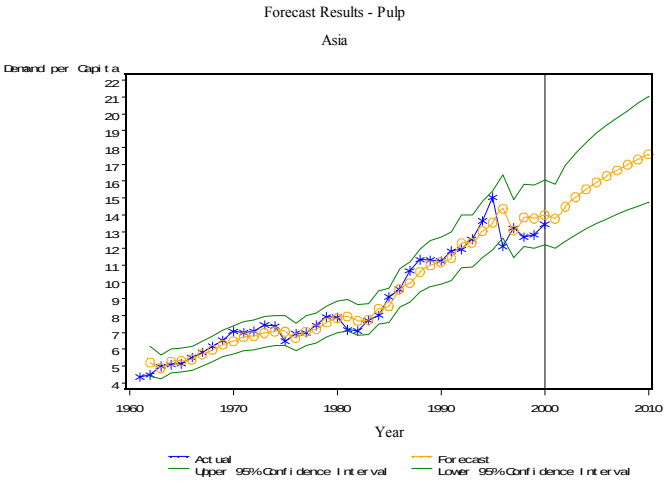

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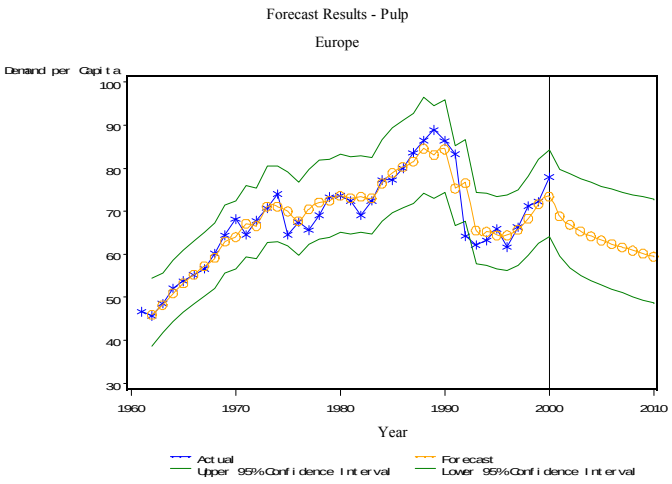

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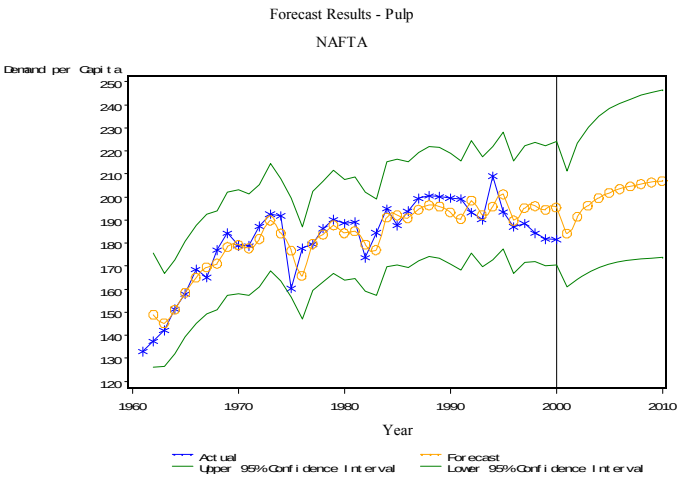

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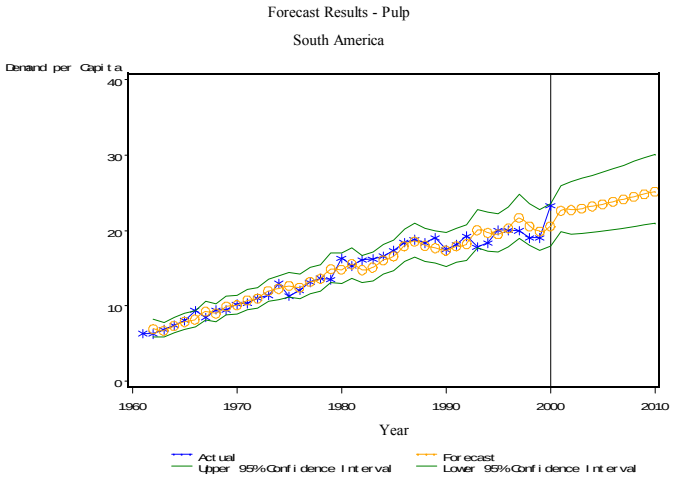

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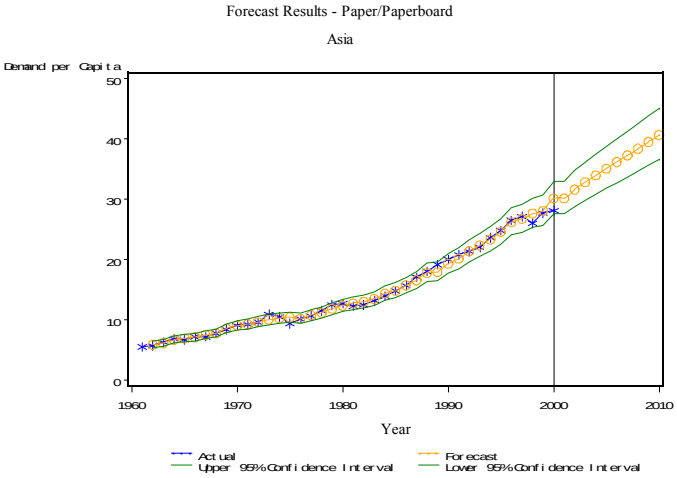

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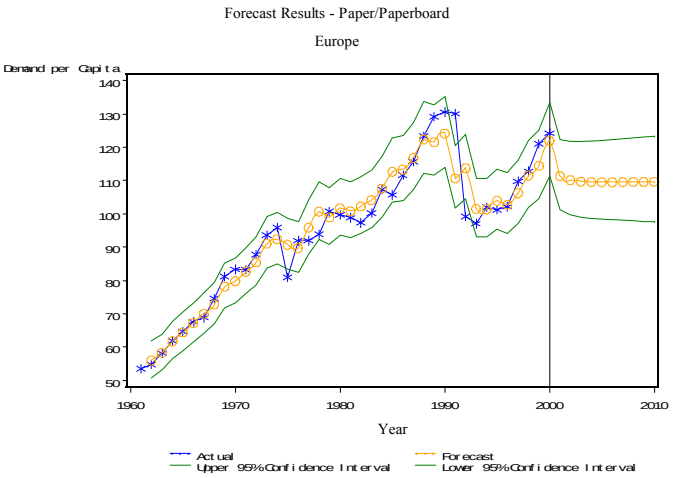

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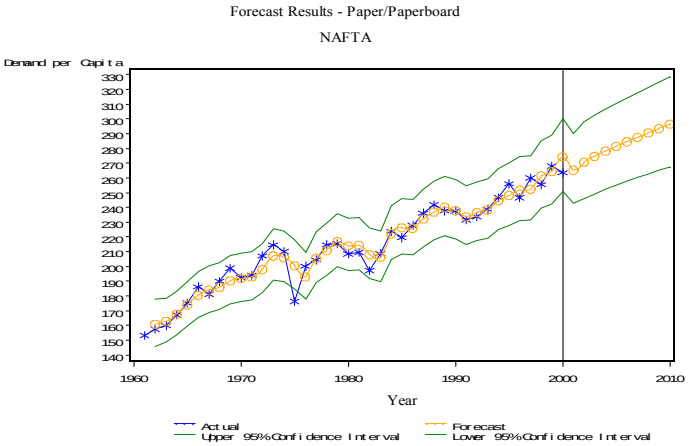

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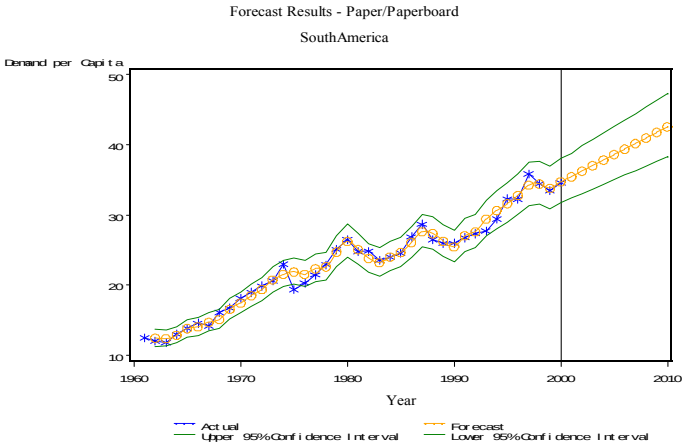

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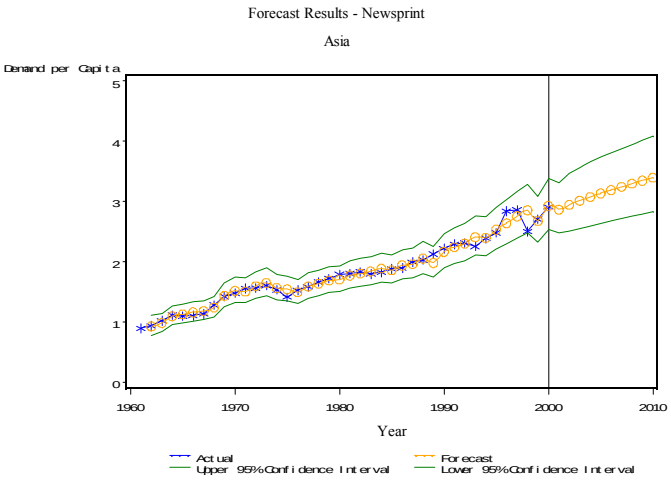

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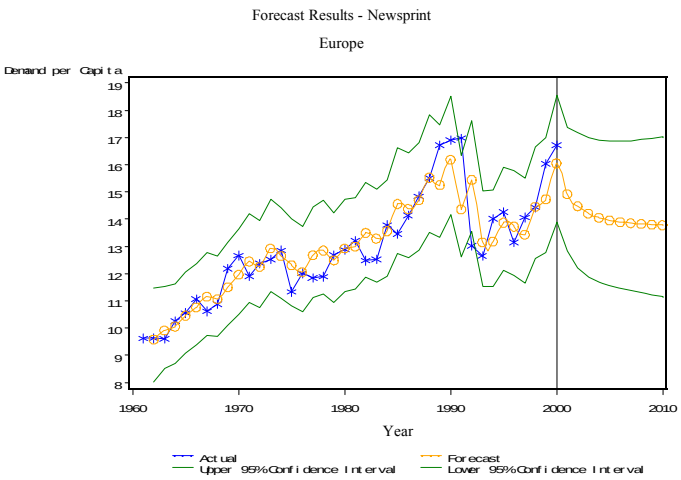

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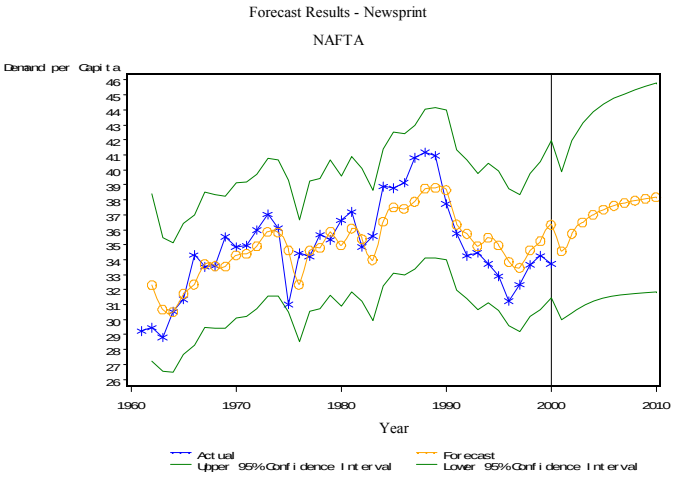

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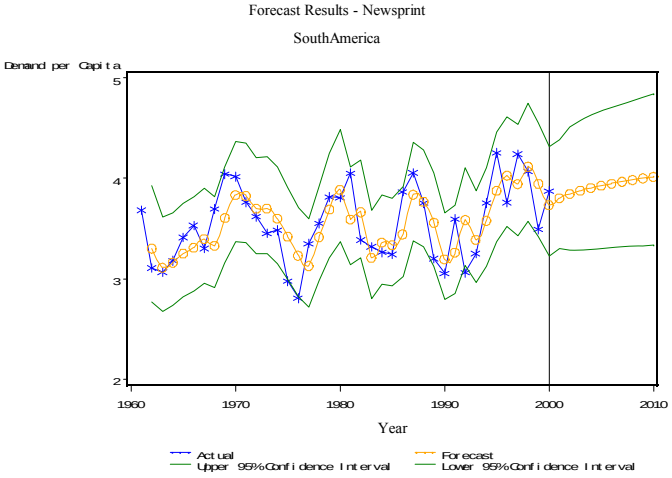

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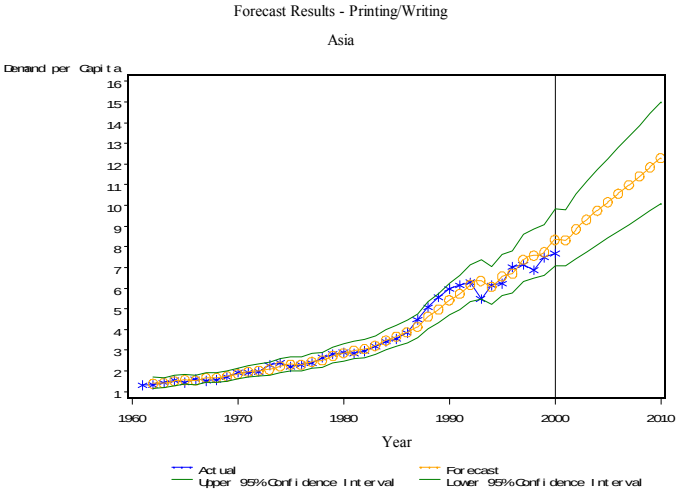

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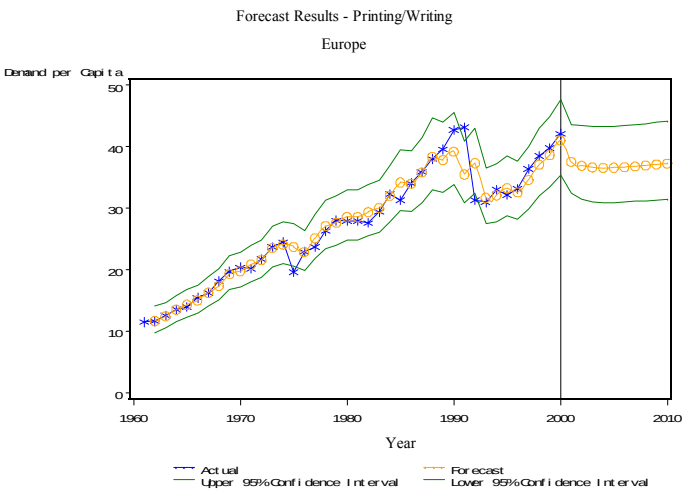

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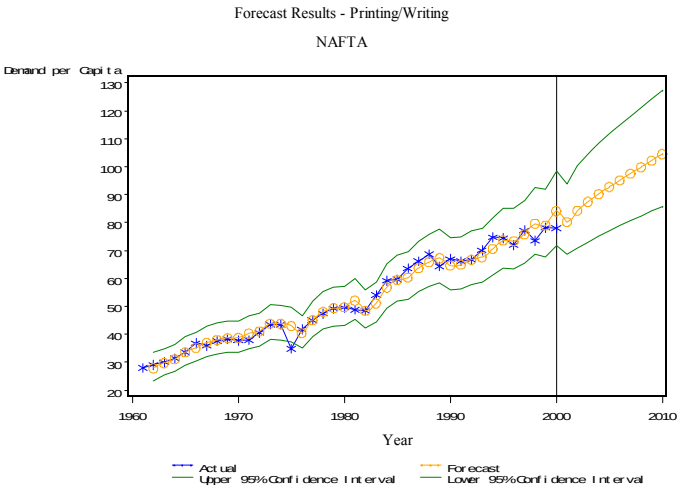

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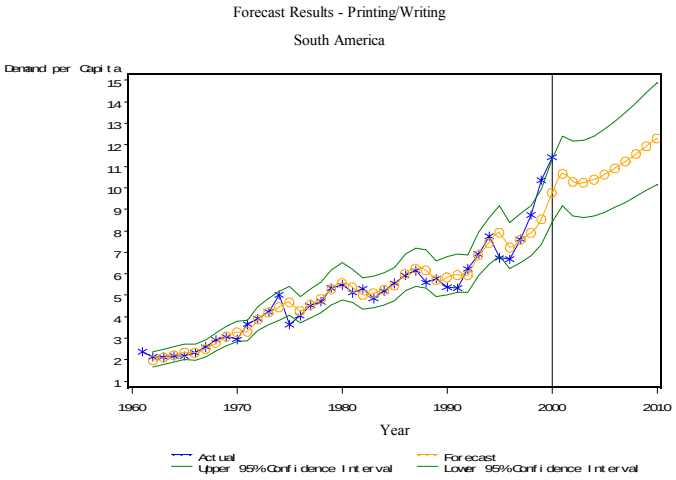

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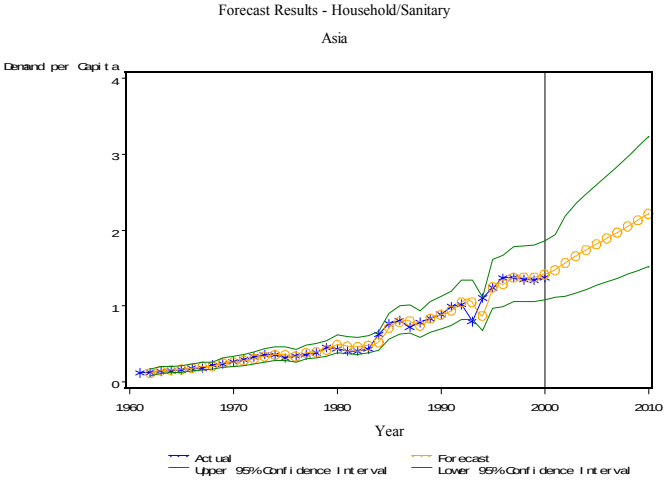

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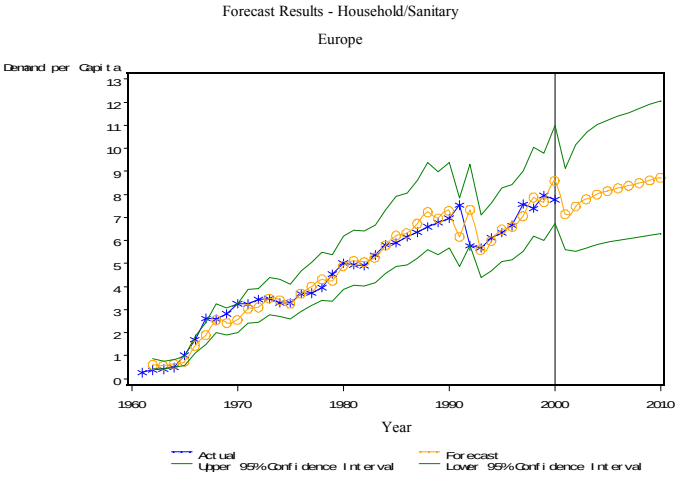

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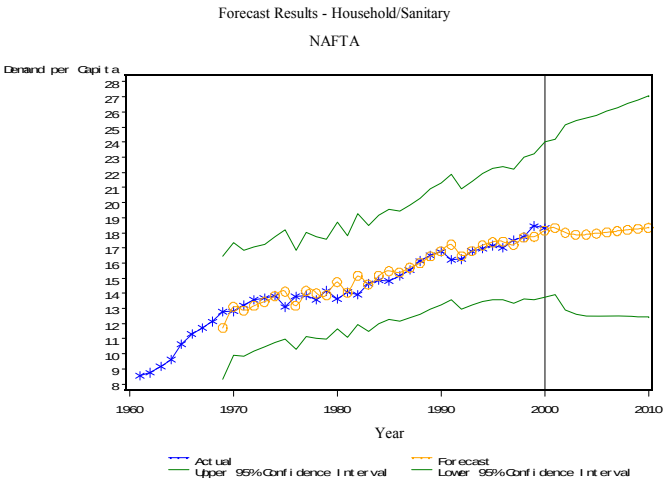

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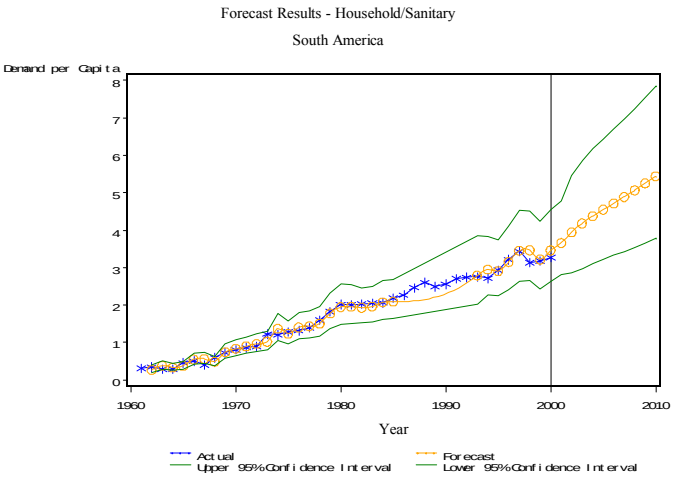

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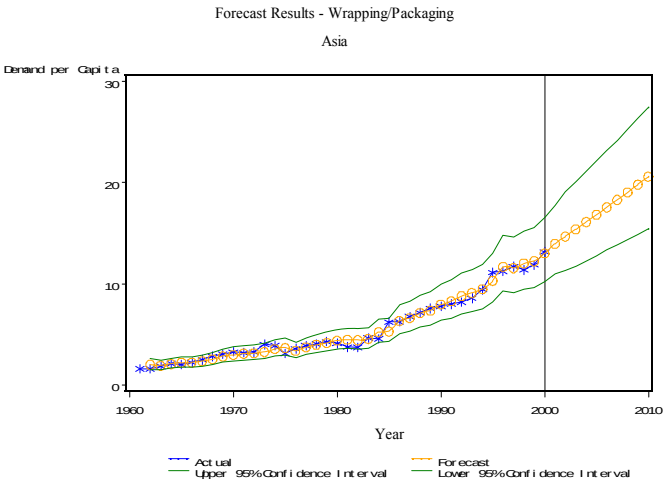

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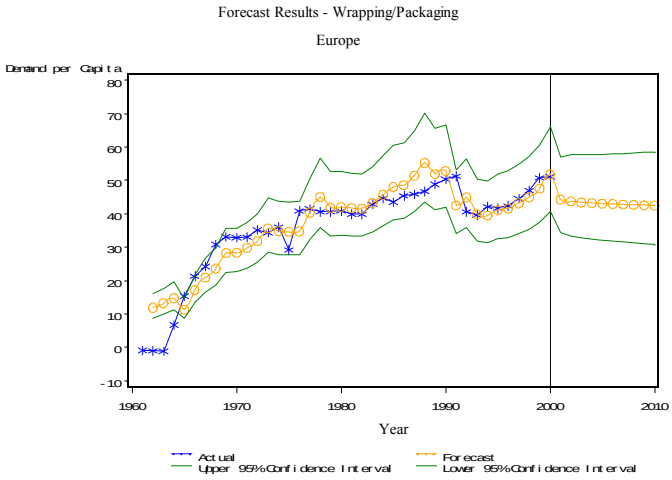

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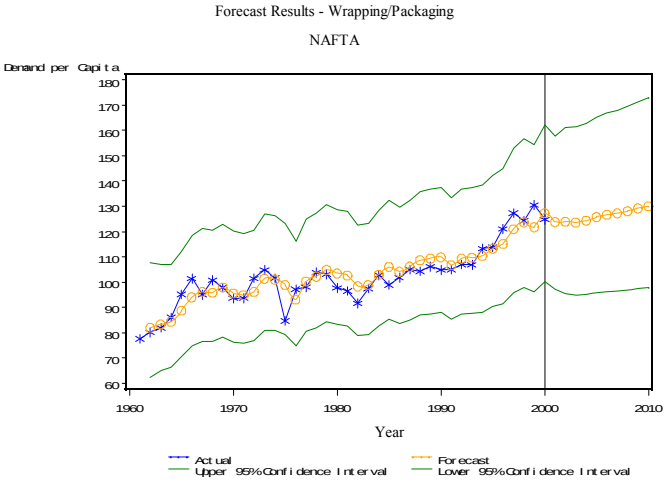

Figure 270

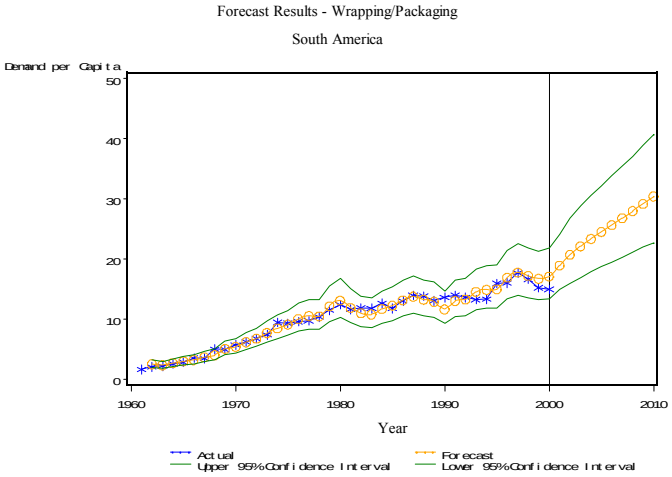

Figure 28