THE CHINESE DAIRY SECTOR: INTERREGIONAL AND INTERNATIONAL TRADE PATTERNS (IMPLICATIONS FOR MODELING, MARKETS, AND DEVELOPMENT POLICY)

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THE CHINESE DAIRY SECTOR: INTERREGIONAL AND INTERNATIONAL TRADE PATTERNS (IMPLICATIONS FOR MODELING, MARKETS, AND DEVELOPMENT POLICY)

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Huiyuan Zou

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Huiyuan Zou, Ph.D.

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Rising values of Chinese dairy imports[1] in recent years generated studies exploring the market potentials for future importing. These studies typically treat the country and its population as uniform and undifferentiated, with homogeneous consumption and production patterns, ignoring the fact that demographic and geographic features are very different across China. At the same time, China's milk production is expanding rapidly, and unevenly in the last 20 years.[2] The supply of milk, a highly perishable commodity, makes the geographic location of production and spatial price differences important factors in defining the availability of milk to populations across the country. The scenarios of inter-regional trade of milk powder and other storable dairy products across China are emerging. This paper is devoted to building an inter-regional dairy trade model for China, and predicting its dynamic internal dairy trade flow under free trade scenario.

This paper updates and summarizes dairy product consumption and supply trends in China, and divides China in four regions. Panel data is used to check consumer and producer responses in different regions, and, at the same time,

[1]China's net import value of milk (Condensed + Dry + Fresh) was US $288 million in 1992 (Zhou and Novakovic, 1996), while in 2004; it reached US $515 million by FAO data.

[2]In 1990s, China's milk production was considered as a small-size in the world; in 2005, China was ranked number seven among the major milk producing countries, with nearly 20 million tons of total milk production.

serve as a test for the hypothesis that China's dairy consumption preference and production patterns are different across the country. Partial equilibrium is the framework used to build the inter-regional dairy trade model.

Our results show that in the major milk producing of Northwestern China producers will suffer most and local consumers may not benefit that much. Eastern China, the richest area, is not benefiting as much from free trade since its high income consumers are not that price sensitive. This region will continue to be the largest importer among the four regions. Inland China and Western China are less price sensitive in production but more price responsive in consumption. With price reduction under free trade, these regions gain more and a free trade policy will stimulate the imports in these two regions.

BIOGRAPHICAL SKETCH

Huiyuan Zou was born on November 1st, 1978, in Hefei, Anhui Province of China. In 1996, she attended Anhui University, in Hefei. She received her B.A. in 2000 with a minor in Finance. In August 2002, she attended the Graduate School at Oklahoma State University, Department of Applied Economics and began her new exploration in Agricultural Economics. She obtained her M.S. degree in Agricultural Economics in July 2004.

To My Family

ACKNOWLEDGEMENTS

After giving birth to my son, William, I deeply feel to complete a dissertation is even more difficult than to deliver a baby. It is more challenging in persistence and many other aspects. The completion was achieved under many people's teaching, advice, help and encouragement. I would like to thank Professor Andrew M. Novakovic, Nancy H. Chau and Tim Mount for their precious guidance and advice. I am so grateful that I could have these wonderful and caring professors in my committee.

I would like to thank my PhD. Advisor Professor Andrew Novakovic. This dissertation may never be completed without his guidance, advice and encouragement step by step. He strongly supported me for nearly six years, encouraged me and helped me during my most frustrated and puzzled time in PhD. Progress, spent time and energy taking me to field trip in China's dairy farms, in 95 degrees summer, to verify our hypothesis. Besides academic guidance, he and his wife will always be there to offer great advice in my life, I never felt helpless in Ithaca during these years, which made severe winter much bearable. From him, I am learning far beyond knowledge in dairy industries, dairy marketing, and public policies, I learned scientific and honest attitudes toward research; positive and optimistic attitudes toward life, which will benefit me all my life. I also would like to thank Professor Nancy Chau, who also supported me and encouraged me at the time when I needed them most. I am grateful for her going through my dissertation methodology again and again nearly hand by hand with me in her office, revising my dissertation even for a small word, and caring me like a big sister. I would like to thank Professor Tim Mount. I benefited not just from his teaching and guidance for research methodology. He spent lots of time, nearly twice a week, on meeting me to review models and results, guiding me to new modeling, and introducing me to eclectic market. Without my committee members, this dissertation would be mission impossible.

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CHAPTER 1
INTRODUCTION

1.1 Market Context

In 1996, Zhou and Novakovic predicted that Chinese dairy market would rapidly grow as its fast -growing economy would continuously increase people's income and the rising middle class in large cities and coastal cities would increase their demand for high-protein food. Moreover, trade and financial reforms in China would reduce business barriers and result in increased dairy trade as well as domestic production. Recent data proves that prediction. In the 1990s, China's milk production was small among world dairy markets. In 2005, China was ranked seventh among the milk producing countries, with nearly 20 million tons of total milk production. Today it is the fourth in the world and rapidly growing consumption of milk and dairy products in China also falls into the patterns predicted by Zhou and Novakovic[26]. Since the mid-1990s, demand, especially that in major cities like Shanghai, has exploded. Accompanying fast economic development, Chinese income is increasing, urbanization is accelerating, and people's dietary choices are changing. Milk and dairy products have become daily consumption items instead of only high-nutrition foods reserved for infants or sick people. Persistent population increases provide another driver for the demand for milk. Tastes have also switched from condensed milk powder to a variety of dairy products, including fresh milk, yoghurts, and ice cream. The rapid rise in consumption also corresponds to greater imports from the rest of the world. In 1992, China's net import value of milk in fresh, condensed and dried forms was US$288 million[26], while in 2004; it reached

US$515 million according to FAO data. China's rising import values in the recent ten years, with the help of lower tariffs after its entrance to WTO, drew attention from main dairy exporting countries and generated studies exploring its demand and supply trends, and import market potentials. These studies have described supply and demand trends in detail.

1.2 Research Questions

Previous econometric studies of Chinese supply and demand typically aggregate over the vast China market. While understandable to some extent, this approach belies the fact that demographic and geographic features are very different across China, regional consumption amounts and behaviors correlated with income are very different. Urban people generally consume more dairy products than those in rural areas due to income and availability. However, some ethnic minority rural residents in western and northern China have long had milk as part of their diets while most Han people who live in eastern China do not. This is also true of all ethnic groups in tropical regions of the southwest. National demand estimation cannot reflect these very different demand responses across China. By the same, taken markets response derived from household surveys from areas where dairy is either part of people's diets or from large cities where dairy products are more accessible may not be a satisfactory reference for exporters or scholars who would like to know the country's market more completely.

As a perishable product, milk and milk products face greater transportation barriers than many, if not most, other agricultural products. As everywhere else in the world, this causes some restrictions in interregional trade. Milk supply in China, although lagging growth in demand, is expanding rapidly, especially in the sub-urban areas of eastern China. Although interregional trade in bulk milk is not economic, it is possible to have interregional trade of milk powders and many other dairy products across China. Capturing these considerations and complexity in a Chinese dairy market analysis necessitate a spatial view.

From a broader point of view, China, as an emerging market for global trade, has gained attention about its national total import or export potentials in various agricultural or non-agricultural products. Foreign industry and Chinese policy makers are interested in projections about China's market, i.e. in which sector of China to invest or where to invest. China's policy leaders have begun to direct investment and dis-investment decisions and incentives based on their analysis of production and import trade offs. This paper will use regional analysis of dairy markets for China and contribute to future agricultural or non-agricultural analysis for China's interregional markets. The centered questions of interest here are where and to what extent will milk production and dairy product consumption grow within China, and what are the implications for interregional and international trade. Empirical models will be developed to determine where and what will be the net production and consumption tendencies within China. This will then be linked to an international trade model that will include partial and limited international trade. The analysis involves three steps: (1) division of China's dairy markets into regions according to its demographic and geographic characteristics, i.e. economic development, dietary habits and agricultural production features; (2) estimation of China's regional dairy products production and consumption differences in response to income and price changes; (3) determination of regional production, consumption and trade trends under a free trade scenario.

1.3 General Research Design

In the next chapter, we will describe different dairy product consumption patterns in urban and rural China, which are connected with different ethnic groups' diet habits, different regional income levels and different market access for different regional residents. Also, we will describe different regional production systems mainly due to different geographic situations and weather conditions across China. All these descriptions will pave the way for the regional divisions within China at the end of this chapter. In Chapter 3, we will focus on modeling consumer behaviors across China. In order to achieve this goal, we will explore the dairy consumption data available in China, which include basic economic data such as regional dairy product consumer prices, regional income levels and regional consumer price index. We will compare cons and pros among different demand functional forms that are widely used in recent literatures. Since our data is collected separately for urban and rural areas based on household budget, Almost Ideal Demand Systems Model (AIDS), which is proved consistent with known household budget data, is the most ideal one for us to derive regional consumers' responses to changes in prices and incomes.

As a recently developed livestock sector, dairy production data are even not as complete as consumption data in China. In Chapter 4, we will present basic regional milk production data that are available, including recent 11 years' regional milk production, milk prices, and feeding stock prices. Due to the limitation of production data in China, and sharply different regional milk production growth trends in recent 10 years, it is challenging to use one form of production functional forms to reflect such different regional production trends. We would use the dynamic Nerlove form to model those regions with sharp increase in production, and use static form to model those regions with flat milk production growth in recent 10 years. We will then derive producer responses to different price changes.

In Chapter 5, we will discuss dairy trade policy in China, including its history, its changes with WTO accession and what is needed to be reformed. We will present survey data to show the trade liberalization impact in China, especially those in dairy sectors. We will discuss how our free trade impact analysis will be different from these literatures, and what contribution we would like to make to existing literatures. We will review existing trade policy analysis model frames, including partial equilibrium and general equilibrium, describe dairy market characteristics, and build up China's regional dairy markets partial equilibrium model. Under this frame work, we will present how regional dairy production and consumption will change given certain trade policy.

In Chapter 6, we will first summarize our research questions and results. Then we will comment on what are our results implying for marketing strategies in China, and what are choices for policy makers. We will also suggest what is needed for future research.

CHAPTER 2

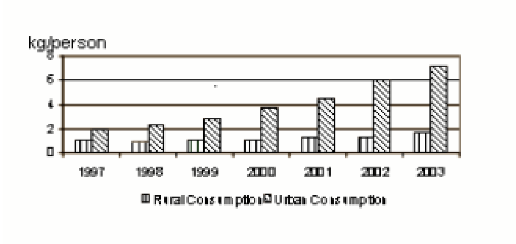
DAIRY PRODUCT CONSUMPTION AND PRODUCTION PATTERNS IN CHINA, IMPLICATIONS FOR REGIONAL DIVISION

2.1 Different Consumption Patterns By Region

Current information indicates that dairy consumption in China is uneven between urban and rural areas. This is closely related to income disparity and market accessibility. Ethnic difference also contributes to the uneven consumption across China.

2.1.1 Uneven Consumption by Urban and Rural Residents

According to the data from ”China Urban Residents Income and Expenditure Statistic Yearbook” and ”Rural Household Survey”, published by the China National Bureau of Statistics (CNBS), there is an increasing gap between urban and rural per capita consumption of milk and other dairy products. There are multiple reasons behind the increasing gap. Income disparity is commonly mentioned by many studies as the cause of the consumption difference. Figure 2.1 illustrates how rural and urban household income differences between 1997 and 2003 are related to per capita dairy products consumption. With the gap between urban-rural incomes growing wider after 2000, the consumption difference of dairy products also enlarged. Beyond income disparity, education differences between rural and urban households, different access to media and information, and the diet globalization in urban areas all contribute to the increasing urban rural gap in dairy products consumption.



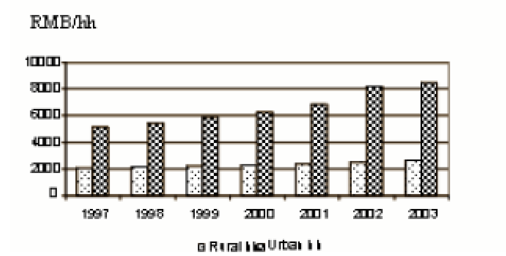


Figure 2.1: Division of economic areas by China Statistical Bureau

Sources: CNBS, Rural Household Survey, China Urban Residents Income and Exp. Statistic Yearbook 1998-2000

Table 2.1: Dairy Products Consumed by Urban Households by Income Level Year 2003

Income Level (RMB)	**Total**	**Lowest**	**Low**	**Lower Middle**	**Middle**	**Upper middle**	**High**	**Highest**
Living expenditures	6510.94	2562.36	3549.28	4557.82	5848.02	7547.31	9627.58	14515.68
Food expenditures	2389.56	1211.21	1578.82	1906.29	2268.36	2729.92	3296.61	4280.02
Exp. on Dairy	124.7	38.31	66.24	95.63	122.9	153.33	189.32	228.01
Quantities purchased (kg)								
Dairy products total	21.71	7.70	12.66	18.09	22.12	27.16	31.36	33.25
Milk	18.62	6.71	10.85	15.51	18.94	23.43	26.82	28.29
Milk powder	0.56	0.31	0.46	0.57	0.61	0.62	0.62	0.63
Yogurt	2.53	0.68	1.35	2.01	2.57	3.11	3.92	4.33

Sources: China Urban Residents Income and Exp. Statistic Yearbook, China Statistical Yearbook, 2004

Table 2.2: Dairy Products Consumed by Rural Households by Income Level Year 1999

Income level (RMB)	**Lowest**	**Lower**	**Middle**	**Higher**	**Highest**
Living expenditures	3897.59	5267.05	6605.25	7815.66	14240.05
Food expenditures	2111.4	2734.1	3192.13	3628.16	5212.65
Consumption of milk from Cow/Goat(kg)	1.42	1.29	2.18	3.34	4.5

Sources: National Rural Social-Economic Survey Data Collection 1986-1999

2.1.2 Different Dairy Products Consumption by Income Levels

Income also plays a determinant role in what amount and types of dairy products are consumed by urban and rural residents. Table 2.1 and Table 2.2 describe the quantity and types of dairy products consumed by different income level both for urban and rural areas. The urban data are derived from the China Statistical Yearbook and China Urban Residents Income and Expenditure Statistic Yearbook. The rural household dairy consumption data by income levels are only available from the National Rural Social-Economic Data Collection, 1986-1999, published by the Ministry of Agriculture (MOA). Although the data are not recent, they provide insight into the dairy consumption differences caused by income in rural China.

From the limited data source, we still observe higher milk consumption per rural household with higher incomes. According to other reports, rural consumption of milk comes from either their own production, especially the case among minority households in western China, or from purchased milk powder. This is understandable, for the income of many rural households is comparable to that of lower income households in urban areas, whose main dairy consumption consists of milk powder.

2.1.3 Uneven Consumption by Economic Regions and Ethnic Groups

Despite the urban and rural household income disparity, China's economy is not evenly developed across east and west. Table 2.3 describes the China Sta-

Table 2.3: Division of economic areas by China Statistical Bureau

Economic Area	Western China	Middle China	Eastern China
Ag. Production	**Pastoral Area / Ranch Area**	**Cropping Land**	**Cropping Land/ Sub-Metro**
Provinces	Tibet, Inner Mongolia, Xinjiang, Ningxia, Qinhai, Shaanxi, Gansu, Sichuan, Guangxi, Yunnan, Guizhou, Chongqing,	Heilongjiang, Shanxi, Henan, Jilin, Hubei, Jiangxi, Hunan, Anhui	Beijing, Tianjin, Shanghai, Shandong, Hebei, Jiangsu, Zhejiang, Guangdong, Fujian,Hainan,Liaoning,

Table 2.4: Regional GDP and Rural Labor Proportion

Regions	Per Capita Gross Regional Product(yuan/person)	Percentage of Rural Labor in Total regional Population
Eastern China	**16306**	**36.6%**
Middle China	**7775**	**41.1%**
Western China	**6216**	**41%**

Sources: NBS, China Statistical Yearbook 2003

tistical Bureau's division of east, central and west regions by economic development. Many Chinese data resources, such as the National Rural Social-Economic Data Collections, divide the country into three economic areas: western, central and eastern China. Eastern China has the highest urbanization ratio, clustered by metropolis' like Beijing and Shanghai; the fastest economic development, and the highest urban and rural household incomes. Western China is the least populous, and the least economically developed region. It is the focus of poverty reduction efforts of the Chinese government over the next 20 years. Table 2.4 shows the difference in the regional per capita gross domestic product (GDP) and rural population compositions.

Table 2.5: Per Capita Consumption of Major Consumer Goods in Rural Households of National and 12 Western Provinces (Autonomous Regions, Municipality) at the Year-end

	2000		2003	
Item (kg)	**National Total**	**12 Western Provinces**	**National Total**	**12 Western Provinces**
Grain (Unprocessed)	250.23	240.77	222.44	214.47
Fresh Vegetable	111.98	103.02	107.4	100.75
Meats, Poultry and Related Products	18.3	20.15	19.68	23.24
Eggs and Related Products	4.77	2.24	4.81	2.41
Milk and Related Products	1.06	2.3	1.71	2.87
Fruits and Related Products	18.31	14.79	17.54	14.69

Sources: NBS, China Statistical Yearbook 2003

Inner Mongolia, Tibet, Ningxia, Guizhou and the remaining eight western provinces are the main provinces in which ethnic minorities such as Mongolian, Hui, Tibetan reside, and they account for the majority of the population. Western households are traditional milk consumers and their consumption contributes a large proportion of the national milk consumption. Table 2.5 ”Per Capita Consumption of Major Consumer Goods in Rural Households of National and 12 Western Provinces (Autonomous Regions, Municipality) at the Year-end” shows that the western rural households consume nearly twice the national average of milk and dairy products. Their consumption, with their comparatively lower per capita GDP and household income, is explained by consumer preference from diet habits and the availability of alternatives.

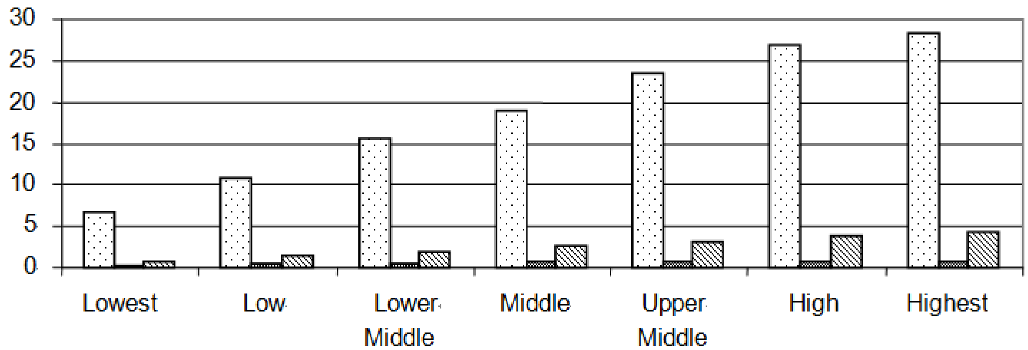


Figure 2.2: Urban per capita Dairy Products Consumption in kg by Income Levels Year 2003

Sources: NBS, China Urban Residents Income and Expenditure Statistic Yearbook, China Statistical Yearbook, 2004

2.1.4 Trends in Processed Milk Products Consumption

Table 2.1 shows that as income increases so do expenditures on processed dairy products. Consumption of fresh milk increases with income levels, just as some studies have suggested there is a Chinese preference for fresh foods[26]. Furthermore, the rise in milk powder consumption slows with income increases, consistent with the fresh food preference. Yoghurt shows a strong and close relation to income level. In conclusion, as Figure 2.2 shows, higher level income urban households enjoyed more fresh milk, and yoghurts, rather than purchasing more milk powder. We should expect different income elasticity for these dairy products and different substitution rates between these three dairy products for households at different income levels.

There are no available data showing detailed dairy consumption for rural residents. However, we could refer to the income effects in last section, rural residents consumption of processed dairy products would most likely follow the pattern in urban areas. The more income they have, the more fresh products they consume. This might be true for eastern and central regions. We shall pay attention to those in the west, who have a long history of milk production and consumption. They may consume more yoghurt-like products, made by households themselves. This informal production would not appear in the data.

2.2 Different Milk Production Systems and Trends across China

Milk production, like many other agricultural livestock products, is constrained by weather, and natural resources. Given its broad geographic coverage, China's natural resources and weather are different across south to north and east to west.

2.2.1 Different Agricultural Production Systems

From milk production input point of view, natural pastures are the most economic natural feeding stock for cows. They are mostly concentrated in Inner Mongolia areas, as Figure 2.3 shows. Tibet (Xi Zang) is abundant with high land pasture areas. For the high latitude reason, these areas are not ideal environment for dairy cows. Corn is also another important feeding stock, and it is mostly grown in North –East China. Thus western China is granted with the best natural resources that are needed for milk production.

This area has the majority of milk cows, and livestock production is its tra-

Figure 2.3: Different Agricultural Production Systems in China

ditional agricultural sector (Table 2.7). Its vast grasslands provide important inputs in milk production, feeding stock (grass) and lands. Eastern China is the most urbanized with highest per capita GDP. Agriculture is not a large component of GDP. Due to limited lands, livestock production value counts less in agriculture sector than that for the west. While for western and northern (Inner Mongolia) China, whose total and per capita GDP are both the lowest, agriculture sector production value is more important. With more land and traditional diet habits, livestock production value counts for 70 percent of total agriculture production value in the west. Central China's economy is performing as well as the eastern China does. Compared with least-populated and grassland abundant western China, Central's lands are more limited and certain portion of them are used for cropping plants production (Table 2.6). Cows, in general, prefer cool and dry climate to humid and hot climate, together with feeding

Table 2.6: GDP, Production Value of Agriculture sector and Livestock sector in Three Economic Regions

Area	**Total GDP** (in 1000 Million RMB)	**Agricultural GDP** (in 1000 Million RMB)	**Livestock GDP** (in 1000 Million RMB)	**Percentage of Ag. Sector In Total GDP** (%)	**Percentage Livestock in Ag. GDP** (%)
East	95305.75	7427.7	4698.9	7.79%	63.26%
Central	40349.51	6128.5	4235.4	15.19%	69.11%
West	27585.17	4582.1	3239.5	16.61%	70.70%

Sources: NBS, China Dairy Yearbook 2005

stock resources, we shall expect western part of China be ideal milk producing areas.

2.2.2 Different Dairy Farms with Different Technology and Scales

From the technology point of view, Eastern China, or suburban areas, has been under technical support for certain years. Although land is limited, their higher production technology or management skills bring it a higher yield per cow. Its total milk output is second to the level or western China producers, although it has only one-fourth the milk cows as western China (Table 2.7). Eastern China has more large scale farms, and these farms enjoy a higher production technology, although with the most limited lands. The purpose of production, the agricultural environment and demand stimulation for four regions are different. The main reason for milk production in western China traditionally is for self-consumption. The minority Chinese people who own dairy animals consume a

Table 2.7: Number of Animals Owned by Regions, Year 2002

Type	Number / Head				Composition / %			
	Total	Eastern	Central	Western	Total	East	Cent.	Western
Cattle	70,213,955	17,664,017	31,995,837	20,554,101	100	25.16	45. 57	29. 27
Buffalo	20,865,755	7,211,113	6,450,841	7,203,801	100	34.56	30.92	34.52
Milk Cow	3,328,528	429,886	1,214,668	1,683,974	100	12.92	36.49	50.59

Sources: China Agricultural Yearbook 2003

majority of their own products. Their dairy products not only come from cow milk, but also from horse milk, goat milk, and camel milk. It is widely recognized (e.g. Ma et al.[16]) that Han Chinese (majority) who live in the central and eastern China do not have milk in their traditional diets. Rural households raise cows in the confinement, mainly for selling the milk. At the same time, the rising demand from cities clustered in eastern China further promotes technology improvements for the eastern dairy-producing households. With less land available and fewer pasture areas, improvements in cow yields are in urgent need. Recently, not only are high yielding cows imported into China from countries like the U.S., but so are many other genetic technologies such as embryos. The minority of Chinese people have led a nomadic lifestyle for centuries. Such a lifestyle makes it hard to adopt technology improvements such as artificial insemination or cross breeding. It would be comparatively easier to do these for the fixed confinement raised cows in the east or middle. From farm sizes point of view, the small holders are mainly concentrated in the western China (Table 2.8), small dairy farms with cows from 5 to 19 are the dominant majority in milk production, where they own majority of milking cows. Although eastern China is not concentrated in agricultural production, it has the majority of largest scale dairy farms in China, up to ones with over 1000 cows. Central

Table 2.8: Distribution of Dairy Farms and Their Scale in Economic Regions

	Number of Farms (farm size measured by number of cows)					
Area	**5~19**	**20~99**	**100~199**	**200~499**	**500~999**	**above1000**
East	70988	14812	1178	605	263	122
Central	66842	7675	502	214	46	27
West	149413	17105	1141	140	57	31

Sources: China Dairy Yearbook 2005

China is in between of the east and west in terms of farm sizes.

2.2.3 Different Geographic Distances to Major Consumption

Milk is a perishable livestock product. Consumers consume different types of processed dairy products, including fluid milk, yoghurt and ice cream, etc. Processors play very important role in connecting milk farms and consumers. The location of milk producing farms is very important (Figure 2.4). If they are too far away from major consumers, such as metropolitan areas, it might not be economic for processors to collect milk from them. From last description of consumption, we know that ethnic groups in China are important consumers of milk, as well as important small household producers.

Table 2.9, Figure 2.5 and Figure 2.6 describe different provinces in China, and ethnic groups in China. As we mentioned in the consumption part, east coastal metro areas, such as Shanghai, Beijing are the major demanding areas for dairy products. From Figure 2.3, we can observe that natural pastures abundant Inner Mongolia is located near Beijing. We shall not be surprised to see its milk production increase in recent years to catering to huge demand increase from

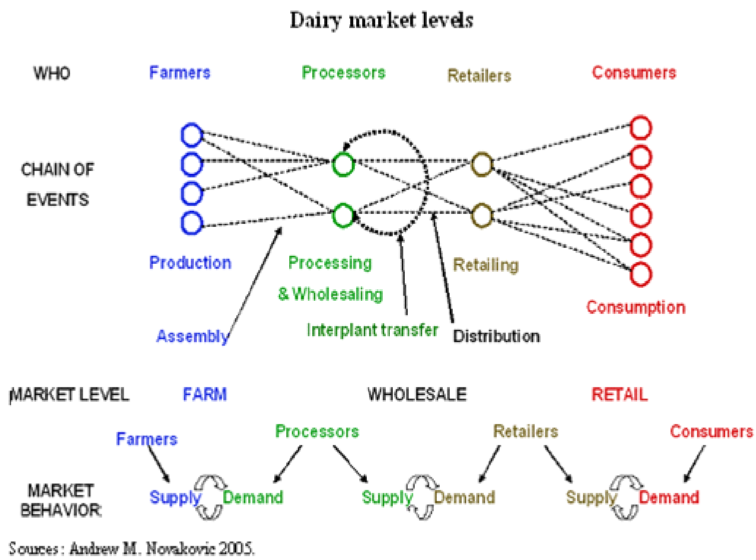


Figure 2.4: Dairy Market Levels

Table 2.9: Geographic Distribution of Minority Nationalities

	Main Geographic Distribution	**Population**
Mongolian	Inner Mongolia, Liaoning, Jilin, Hebei, Heilongjiang and Xinjiang	5813947
Hui	Ningxia, Gansu, Henan, Xinjiang, Qinghai, Yunnan, Hebei, Shandong, Anhui, Liaoning, Beijing, Inner Mongolia, Tianjin, Heilongjiang, Shaanxi, Guizbou, Jilin, Jiangsu and Sichuan	9816805
Tibetan	Tibet, Sichuan, Qinghai, Gansu and Yunnan, Xinjiang	5416021
Uygur	Xinjiang	8399393
Miao	Guizhou, Hunan, Yunnan, Guangxi, Chongqing, HubeiandSichuan	8940116

Sources: China Statistical Yearbook 2003

Figure 2.5: Map of China

metropolitan areas. On the other hand, remote western areas, such as Tibet and Xinjiang are ethnic group concentrated areas, as they maintain a habit of producing milk and consuming milk, we shall expect these western area residents consume more milk with higher income. However, due to their remote locations from current metropolitan areas in the Far East coast, we do not expect them be a major player in exporting milk like Inner Mongolia.

2.3 Implications for Regional Division

We have concluded that consumption in China shows clear difference in quantities with different income, with urban and rural, and with different ethnic

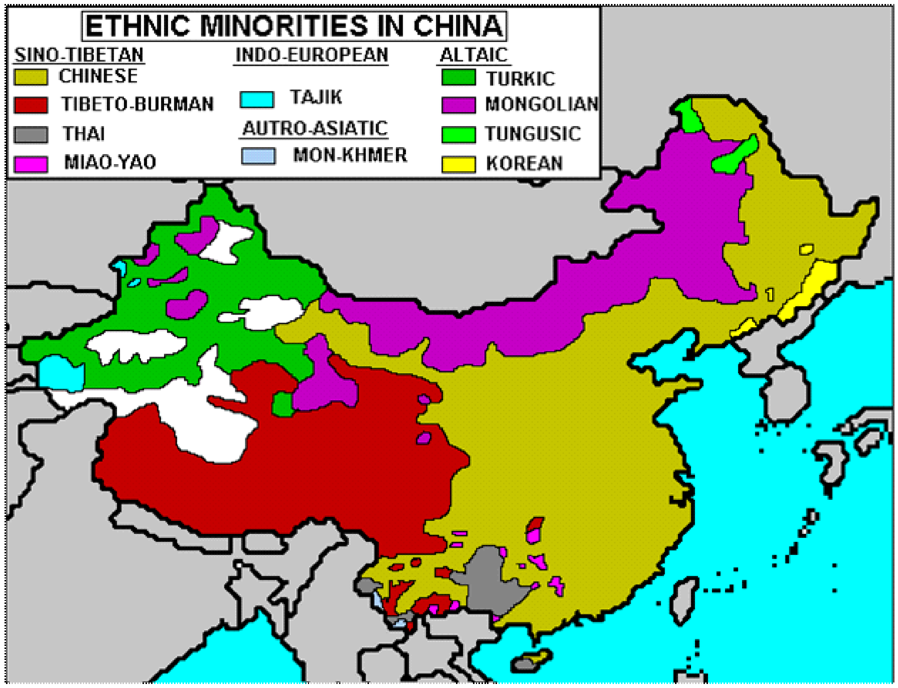


Figure 2.6: Ethnic Groups Distribution in China

groups. Production, on the other hand, shows natural resources difference across northern and southern parts of China, and technology or scale differences across west and eastern economic regions.

As metropolitan concentrated eastern region, as China Statistical Bureau defined, it has the highest income levels compared with other regions of China, and it is the driving force behind the increasing demand. It also shows typical characteristic of modern farm production systems, with larger scales and higher yield per cow, as we observed in the above consumption and production parts. Thus eastern region shall stay as one important region in our re-division of China's dairy markets. The remaining China are composed of ethnic group concentrated areas and central areas.

We have to consider milk producing locations' distances to consumers.

Table 2.10: Regional Divisions

Region 1 **(Milk Tank)**	**Region 2** **(Metropolitan)**	**Region 3** **(Inland Cities)**	**Region 4** **(No Where)**
Inner Mongolia, Heilongjiang, Hebei	Liaoning, Jilin, Beijing, Jiangsu, Shanghai, Shandong, Tianjin, Zhejiang, Guangdong, Fujian	Anhui, Hainan, Hubei, Hunan, Henan, Jiangxi, Ningxia, Shaanxi, Shanxi, Guangxi, Guizhou, Sichuan, Yunnan, Chongqing	Gansu, Qinghai, Tibet, Xinjiang

Among those areas that are abundant with natural pasture and land resources, we could observe that Inner Mongolia, Heilong Jiang and Hebei are such provinces that equipped with feeding stock resources, such as pastures and corns, and nearby locations to metro areas such as Beijing. The remaining ethnic group concentrated areas such as Tibet and Xinjiang, have more lands, and have a long history in producing and consuming milk within households. They do not have easy access to metropolitan concentrated areas as Inner Mongolia does. They might produce for what they need to consume. They could be grouped together.

Majority concentrated inland areas, such as Anhui, Hubei, are limited in land for cows, and do not have the diet habits in consuming milk, which is similar to economically better off areas in the east. However, they do not enjoy high incomes as eastern areas do. It would be natural to group such areas together.

Thus we have Table 2.10 summarizing our regional divisions considering production and consumption characteristics.

CHAPTER 3
REGIONAL CONSUMPTION BEHAVIORS

We have described consumption differences in quantity across China by different income levels and ethnic groups in above chapters. In microeconomic theory, consumer's bundle of consumption will be influenced by income level, that is, how much they could afford to spend. Given certain budget level, or income level, their preferences to different products will be shown in their different responses to responsive prices. In theory, since regional per capita income is different, and regional residents ethnic group composition are different, we shall expect different income and price responses. We need to quantitatively derive income and prices responses for different regional consumers across China to prove our hypothesis. To accomplish this goal, we have to exam what kind of data is available for our quantitative research, and what kind of functional forms we would choose. The following sections will address above questions and show the final results from our estimation.

3.1 Data Description

For urban consumption, data comes from Urban Households Income and Expenditure Survey, conducted by National Statistics Bureau of China (CNBS). From 1992, this survey began to contain the data for dairy products consumption. The survey's provincial level data section shows in certain provinces, the average per capita income, living expenditure, and expenditure on food, non food commodities, including the annual per capita expenditure on dairy products. It does not tell what type of dairy products people consume, nor does it tell how many units of dairy products people consume. However, it is one of the most popular statistical references used and cited by many scholars.

The rural data comes from Rural Households Income and Expenditure Survey, also conducted by CNBS. Like that in the urban survey, the survey's provincial level data section shows in certain province, the average per capita income, living expenditure, and expenditure on food, non food commodities. Different from those surveys in urban areas, some food, like dairy products consumption, was collected as annual per capita consumption in kilograms. It does not tell what type of dairy products people consume, nor does it tell how much money people spent on. Still it is one of the most popular statistical references used and cited by many scholars as the urban surveys.

3.2 Demand Functional Forms

Sadoulet et al.[21] have concluded two broad methodology of functional estimation in their "Quantitative Development Policy Analysis" for demand. The first method is a liner form double log demand function estimated from time series data. This simple structural form has the advantage of showing consumption responses to income and price quantitatively and directly, with the intercept containing other information such as demands shifters. This form of equations is attractive by its simplicity; however, it has a serious drawback, which is whether the equation is actually derived from consumer behavior is doubtful. Besides this time-series estimation, Complete Demand System functional forms are widely used.

The Complete Demand System includes Linear Expenditure System (LES), proposed by Stone in 1954. After him, Theil proposed Rotterman model. Christensen, Jorgenson, and Lau[8] continued the LES study and proposed Translog model. In 1980, Deaton and Muellbauer proposed Almost Ideal Demand System (AIDS)[10]. In their paper, they proved that AIDS model ”gives an arbitrary first-order approximation to any demand system; it satisfies the axioms of choice exactly; it aggregates perfectly over consumers without invoking parallel linear Engel curves; it has a functional form which is consistent with known household-budget data; it is simple to estimate, largely avoiding the need for non-linear estimation; and it can be used to test the restrictions of homogeneity and symmetry through linear restrictions on fixed parameters. Although many of these desirable properties are possessed by one or other of the LES models, such as Rotterdam or translog models, neither possesses all of them simultaneously”. Besides AIDS model’s mentioned merits above, we shall see that our data, especially urban household data matches with AIDS model the most.

An AIDS model has the following functional form as Deaton et al. defined

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(x/P) \tag{3.1}$$

where P is defined as

$$\log P = \alpha_0 + \sum_k \alpha_k \log p_k + (1/2) \sum_j \sum_k \gamma_{jk} \log p_k \log p_j \tag{3.2}$$

and w_i is the expenditure share of product i over living expenditure, $p_j$is the price of product j, and x is the living expenditure.

In situations where prices are closely collinear, it may well be adequate to approximate P as proportional to some known index P^*. One obvious candidate for P^* is Stone’s index

$$\log P^* = \sum_k w_k \log p_k \tag{3.3}$$

where $w_k$is the expenditure on product k over living expenditure.

A system of demand functions requires:

1. Total share of expenditure add up to one ($\sum_k w_k = 1$);

2. Homogeneous of degree zero in prices;

3. Total expenditure taken together, satisfy Slutsky symmetry.

To meet 1, 2, 3, we need to have Equation (3.4) (3.5) (3.6) as described below:

$$\sum_i \alpha_i = 1, \sum_{i=1}^{n} \gamma_{ij} = 0, \sum_{i=1}^{n} \beta_i = 0; \tag{3.4}$$

$$\sum_j \gamma_{ij} = 0 \tag{3.5}$$

$$\gamma_{ij} = \gamma_{ji} \tag{3.6}$$

We divide expenditure into three parts, our w_i are expenditure on dairy products (W_d), nondairy food products (W_{ndf}), and non food products (W_{nf}) over living expenditure. The restriction (3.4) will be satisfied. We will have the price of dairy products (P_d), and the price of non dairy food products (P_{ndf}), which we derived from stone index. We also derive price of non food from stone index (P_{nf}). We impose restriction (3.5) into (3.1), we will have

$$W_d = \alpha_1 + \gamma_{11}\log(p_d/p_{nf}) + \gamma_{12}\log(p_{ndf}/p_{nf}) + \beta_1\log(x/P^*) \tag{3.7}$$

$$W_{ndf} = \alpha_2 + \gamma_{21}\log(p_d/p_{nf}) + \gamma_{22}\log(p_{ndf}/p_{nf}) + \beta_2\log(x/P^*) \tag{3.8}$$

Therefore, we have Equation (3.1) and (3.2) satisfied, and we will restrict Equation (3.3). In our regression. Since it involves cross-equation restriction, the variance-covariance of the residuals plays a part, OLS will be replaced by maximum likelihood estimation. After correcting autocorrelation,we have results presented in Appendix A.

We could expand Equation (3.7) into form as following Equation(3.9):

$$W_d = \alpha_1 + \gamma_{11}\log(p_d/p_{nf}) + \gamma_{12}\log(p_{ndf}) - \gamma_{12} + \gamma_{11}\log(p_{nf}) + \beta_1\log(x/P^*) \tag{3.9}$$

$$W_{ndf} = \alpha_2 + \gamma_{21}\log(p_d/p_{nf}) + \gamma_{22}\log(p_{ndf}/p_{nf}) - \gamma_{22} + \gamma_{21}\log(p_{nf}) + \beta_2\log(x/P^*) \tag{3.10}$$

The estimated parameters from AIDS model do not have straightforward economic interpretation like Double log demand functions. We need to derive Marshallian price and expenditure elasticity from these estimated parameters.

The Marshallian price elasticity for dairy products for our results are:

$$\varepsilon_d = -1 + \gamma_{11}/\overline{W_d} - \beta_1 \tag{3.11}$$

The expenditure elasticity for dairy products is:

$$\eta_d = 1 + \beta_1/\overline{W_d} \tag{3.12}$$

where $\overline{W_d}$ is the regional average of dairy expenditure over living expenditure.

The Marshallian price elasticity for food but non-dairy products for our results is:

$$\varepsilon_{ndf} = -1 + \gamma_{22}/\overline{W_{ndf}} - \beta_1 \tag{3.13}$$

The expenditure elasticity for food but non-dairy products is:

$$\eta_n df = 1 + \beta_2/\overline{W_{ndf}} \tag{3.14}$$

where $\overline{W_{ndf}}$ is the regional average of food non-dairy expenditure over living expenditure.

Due to collinearity, SAS will not be able to estimate equation for (W_{nf}) at the same time with Equation (3.9), however, we could use Equation (3.4) and Equation (3.5)to derive what is needed for (W_{nf}).

We will have Marshallian price elasticity for non-food products as:

$$\varepsilon_n f = -1 + \gamma_{33}/\overline{W_{ndf}} - \beta_1 \tag{3.15}$$

The expenditure elasticity for non-food products is:

$$\eta_n f = 1 + \beta_3/\overline{W_{nf}} \tag{3.16}$$

where $\overline{W_{nf}}$ is the regional average of non-food expenditure over living expenditure.

From Equation (3.9), Equation (3.4) and Equation (3.5),we could derive

$$\gamma_{33} = \gamma_{11} + \gamma_{12} + \gamma_{21} + \gamma_{22}\beta_3 = -\beta_1 - \beta_2\overline{W_{nf}} = 1 - \overline{W_{ndf}} - \overline{W_d} \tag{3.17}$$

The results are shown in Table 3.2 below, which lists all the data we need to calculate the elasticities for Equation (4.2), Equation (4.3) and Equation (4.4).

The values are from our data set and regression results, Table A.2, Table A.4, Table A.6, and Table A.8.

Table 3.1: Coefficient values for the consumption equations

	Region1	Region2	Region3	Region4
$AverageW_d$	0.0136076	0.0137493	0.0106276	0.0143756
$AverageW_{ndf}$	0.4033483	0.4370361	0.4473589	0.4250693
$AverageW_{nf}$	0.5830441	0.5492146	0.5420135	0.5605551
γ_{11}	0.003476	0.005127	0.000593	-0.00127
γ_{12}	-0.00014	-0.00504	-0.005	0.002981
γ_{21}	-0.00014	-0.00504	-0.005	0.002981
γ_{22}	-0.03957	0.131884	0.131884	-0.00247
β_1	0.010655	0.005174	0.005174	0.007347
β_2	-0.22907	-0.13431	-0.13431	-0.24735
γ_{33}	-0.036374	0.126931	0.122477	0.002222
β_3	0.218415	0.129136	0.129136	0.240003

3.3 Results and Implications

After we have tested for heterodasticity and autocorrelation, we derived both Marshallian price and expenditure elasticities for urban areas in Table 3.2. Assume income and living expenditure will be proportional, we could refer income elasticity from expenditure elasticity. We have dropped data for the rural areas in expenditure on dairy products due to the data collection procedure adopted by CNS. Also, given the fact we described in Figure 2.1, that per capita rural dairy consumption is far below that in urban areas, we may assume that rural residents will have the same behavior of dairy products consumption when they reach the corresponding income levels as urban residents enjoy

Table 3.2: Regional Expenditure and Marshallian Price Elasticities

	Region 1	**Region 2**	**Region 3**	**Region 4**
ε_d	-0.755209514	-0.632282289	-0.949375889	-1.095691139
ε_{ndf}	-0.869033798	-0.563920878	-0.570884196	-0.758460817
ε_{nf}	-1.280801362	-0.898022333	-0.903169304	-1.236039072
η_d	1.783018313	1.376310067	1.486845572	1.51107432
η_{ndf}	0.432078925	0.69267985	0.699771257	0.418094885
η_{nf}	1.374611457	1.235128491	1.238252368	1.42815238

now. For urban regions where residents depend on purchasing food for a living instead of producing them, regional economic difference plays an important role. Our results comply with theory. Region 2(including metropolitan such as Beijing and Shanghai) is the most economically developed region, where urban residents have higher income and living expenditure levels. They also have the least price and expenditure elasticities. Diet habits show influence on Region 1, which is composed of Inner Mongolia, Heilongjiang and Hebei urban residents. With concentrated Inner Mongolian minority population, they are much less price elastic than those in economically better off Region 3. Economically lagged Region 4 has the highest price elasticities. Among 4 regions, Region2 and 3 are more urbanized, while Region1 and 4 are mostly referred as Vast West, where population is not that concentrated, provinces' GDP has more shares coming from agriculture. It is interesting to see that Region 2 and 3 share similar price and income elasticities on non-dairy food products, and non-food products, Region 1 and 4 also share similar price and income elasticities on non-dairy food products, and non-food products. As urbanized regions with higher income, Region 2 and 3 are less responsive to price changes in food and non-food products.

It would be arbitrary to judge which part of China would be most importing potential market without looking at their production ability and room for expansion. For example, Inner Mongolia has less elastic price elasticities, but that alone does not mean that their residents would be able to consume more imported dairy products. Milk production in Inner Mongolia used to be for self-sufficiency. Given the facts that Inner Mongolia has large numbers of milking cows and much large pastoral areas, together with its long history of milk production, it may continue to be the milk supplier for eastern and central China. Eastern China (Region 2) may continue to import from its long term dairy exporters such as Australia and New Zealand. The main importing commodity would be milk powder.

The accurate potential for China multi-regional trade and possible potential from importing from its neighboring milk producing countries would need further research. Differentiating China dairy market into different regions provides evidence and serves as reference for future multi-market trade flow analysis in the following chapters.

CHAPTER 4

REGIONAL PRODUCTION BEHAVIORS

Different regions are located in different geographic locations, endowed with different natural resources, and equipped with different levels of infrastructures, such as public transportation systems. The milk tank Region 1 has vast grasslands, such as those in Inner Mongolia. The inland and metropolitan concentrated Region 2 and Region 3 regions are limited in arable lands, and further more, they are under pressure from producing fruits and vegetables to feed nearby cities. As we have discussed, the Region 2 area has more large scale modern farms, which will use less land but more commercial feeding stock. The no where land, Region 4, which are traditional milk producers and consumers, have less large scale farms, and they will use more local feed resources, especially pastures. They have difficulty in transporting their products to meet the demand from Region 2 and Region 3.

The inputs of production, and environmental effects, may also be different across regions for the same scale of dairy farms, for those in the eastern regions, there may be less fixed inputs such as lands; while for those in the western regions, fixed inputs are more important. That is, the underlying production functions for these regions may be different.

If there exist different underlying production functions, and different input proportions, we expect different marginal costs in producing one unit of milk for the same scale of farms across regions. And in competitive markets, the farm gate prices shall be different so that marginal costs are the same as the marginal revenue, which are the purchase prices for milk.

Reflecting different marginal costs, or the shape of supply curves, the price elasticity will be different for dairy farms across regions. We will first test whether production functions are the same across regions and then test their respective producer price elasticity.

First we will describe the available data, and then explain how we choose the production functional forms, and we will conclude our results in the end of this chapter.

4.1 Data Description

So far, the data available for China's milk production are limited. The majority of published studies of Chinese agricultural productivity have used data published in China's Statistical Yearbook (CSY). The data includes yearly provincial production of cow milk, number of dairy cows, and price index of feeding stock. As a newly emerged livestock market, the milk farm gate purchase price was not collected until 2004. Fuller, Huang, Ma and Rozelle [12] claimed that the production data as published in the China Statistical Yearbook to be accurate only through the end of the 1980s. Beyond this date, data shall be adjusted both to reflect the annual variation. Further details of the adjustment procedure can be found in [12]. However, it is the most adopted data set used widely in literatures.

The milk purchase prices will be replaced by urban dairy product consumer price index, assuming the fixed proportion of milk purchase price to final consumer price [23]. We have the above data from 1992 to 2004.

4.2 Production Functional Forms

Two general approaches may be used to attack supply problems empirically, they are constructive methods and statistical analysis of time-series data, where the former one is derived from economic theory, and the later one deals directly in making policy decisions especially with aggregate data.

Beyond these approaches, in production analysis, how farmers will respond to price changes and decide their next year or seasons of production quantity are the crucial parts. There are several schools of hypothesis about farmer's price expectation and their decision of production. They are naive expectation, rational expectation and the Nerlove model. Naive expectation, which is what farmers expect for this year's price will be last year's price, and decision of production will depend on this hypothesis. The critics are that it is too naive in real life. The rational expectation that is this year's expected prices will be a function of all past years' prices. This might be rational, however, it is hard to estimate specific weight we shall place for past years prices. The third group is Nerlove Model developed by Marc Nerlove [18]. Marc Nerlove tried to "obtain measures of the elasticities that are more in line with what we know from studies made on production functions and on farmers' reactions to the allotment and price support programs."[18] His hypothesis for farmers' price responses is that each year farmers change the price they expect to have in the coming year in proportion to the error they made in predicting price before. His model is summarized in the following equations.

This year, for example, farmers' expectation for prices of milk is P_t^*, expected milk price last year is P_{t-1}^*. Actual price last year is P_{t-1}. Let the proportion of the error by which farmers revise their expectations be a constant β, which lies between zero and one, we call this the coefficient of expectation.

$$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*), 0 < \beta \leq 1 \tag{4.1}$$

"It can be shown that the hypothesis, stated in Equation (4.1), that farmers revise the price they expect in proportion to the error they have made in prediction, is equivalent to one in which expected price is represented as a weighted moving average of past prices where the weights are functions solely of the coefficient of expectation".[18] Then we could have

$$P_t^* = \beta P_{t-1} + (1-\beta)\beta P_{t-2} + (1-\beta)^2 \beta P_{t-3} + ... \tag{4.2}$$

Suppose farmers adjust their milk production according to their expected price of this year, which is a function of past years,

$$Y_t = \alpha_0 + \alpha_1 P_t^* + \mu_t \tag{4.3}$$

Since P_t^* are not observable, so we cannot estimate Equation (4.3) quite as we would any other simple equations. We must represent P_t^* in terms of variables we can observe. Equation (4.3) indicates that P_t^* is a linear function of production Y_t. For example, last year's expected price P_{t-1}^*, can be represented by last year's production Y_{t-1}.So that expected price this year is a function of last year's actual price and last year's production. Because that expected price this year is a function of actual price last year and expected price last year. We replace last year's expected price in Equation (3.9) by a linear function of last year's production. Thus we will have

$$Y_t = \pi_0 + \pi_1 P_{t-1} + \pi_2 Y_{t-1} + \upsilon_t \tag{4.4}$$

Nerlove model, as an empirical time-series model, is widely used in milk production analysis. Besides time series analysis, there are two constructive reduced forms of functions concluded in [22]. They are:

1. *Production* as dependent variable

   $Production = f(price/supplyshifters)$

2. Use two separate equations to model *Production*

   $yield = f(price/yieldshifters)$

   $units = f(price/unitshifters)$

   $Production = yield \times units$

Which functional form shall we choose? The answer depends on several considerations. First, from what we have described in the preceding chapters, different regions have different numbers of cows, and endowed with different natural resources. Some of the regions showed faster or sharper increase in total production, some of them showed relatively flat growth in total milk output. It might be possible that one form of production function would not catch up the difference across regions. Second, we have to decide the functional forms in via of the data availability constraints. Data incomplete problem is not unusual in empirical economic research. Empirical researchers are likely to face two problems in the attempt to build the empirical basis of the analysis: incomplete data

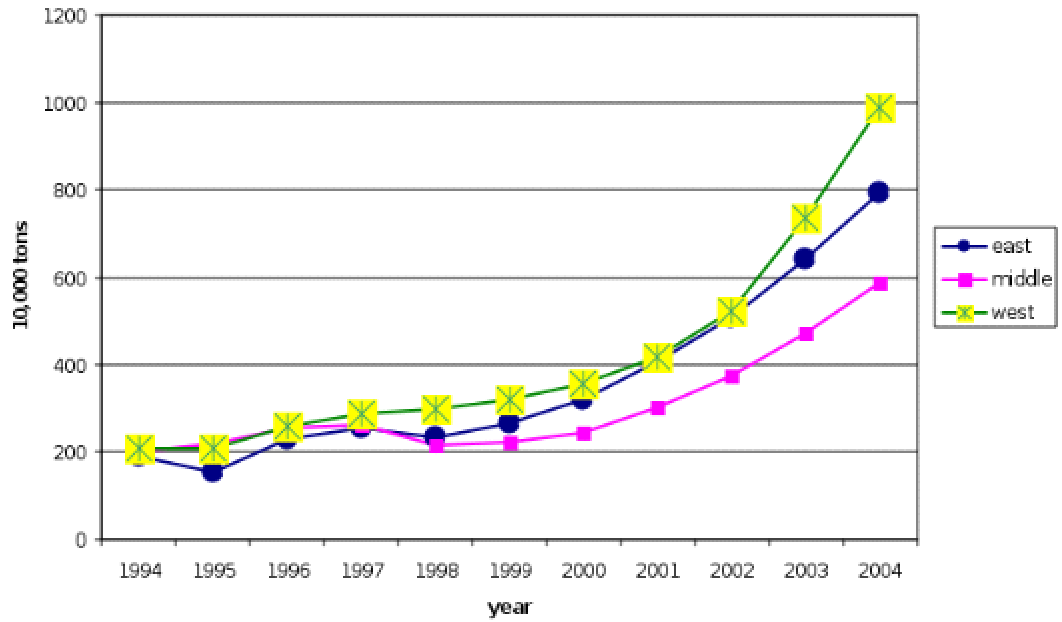


Figure 4.1: Total Milk Production by Economic Regions

Sources: China Statistical Yearbook

for a given item or a flood of figures that are hard to interpret. The task for us here is to make sense of the limited and incomplete available data. We shall identify relevant data and organize them to highlight a feature of the production structure or its performance [24]. Constructive methods, which requires a complete detailed production data, might not be the best choice for us.

In other words, we need to understand the basic trend of production behind the raw data, and use functional forms that not only capture production trends, but also comply with economic theories. We know from Figure 4.1 that in general, all aggregated regional production show upward trends. To smooth the data, it will be helpful to take log form for the cow milk production for each provincial data in each region, and observe detailed provincial trends in each region.

Figures 4.2, 4.3, 4.4 and 4.5 correspond to Region 1, 2, 3 and 4's detailed provincial milk output time series data. We could see that two points need to be addressed. First is different trends in milk production across regions. In general, within each region, provinces in responsive regions share similar trends in milk output. When we observe at the regional level, Region 1's three provinces showed strong upward trend, indicating a trend factor behind its production. Region 2's provinces in general showed sharp increase at an increasing rate recently. A dynamic production function might be appropriate. Region 3 and 4 showed relatively flat increase in log form milk output. Dynamic functional form might not be appropriate. Second point is that every province in each region showed different output level of production. For data per se, each regional data is a panel data which contains both time series and sectional (provincial) information. For each region, the data shows clear provincial difference although sharing the similar trend in production. Panel data may have group effects, time effects, or both. There are two type of model for panel data, the fixed effects, and the random effects. A fixed effect model assumes differences in intercepts across groups or time periods, whereas a random effect model explores differences in error variances. A one-way model includes only one set of dummy variables (e.g., provinces), while a two way model considers two sets of dummy variables (e.g., provinces and year). Figure 4.2, 4.3, 4.4 and 4.5 show in each region, there are clear provincial difference at output level, but provinces in each region generally share the similar trend. A fixed effects model with provincial dummy ($Dummy^*$) would be appropriate, and it is tested that a one-way panel data model with provincial difference, rather than time difference, explain better catering to the data features.

Nerlove model is ideal in capturing dynamic decisions from producers.

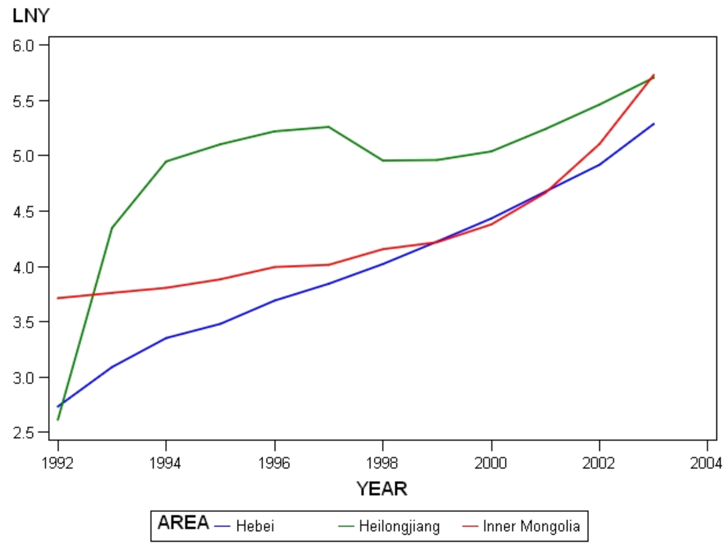


Figure 4.2: Region 1 Cow Milk Output

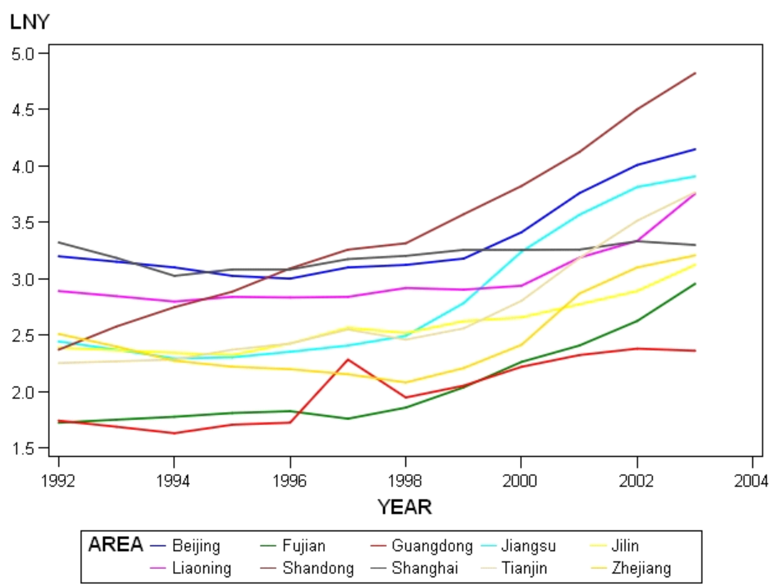


Figure 4.3: Region 2 Cow Milk Output

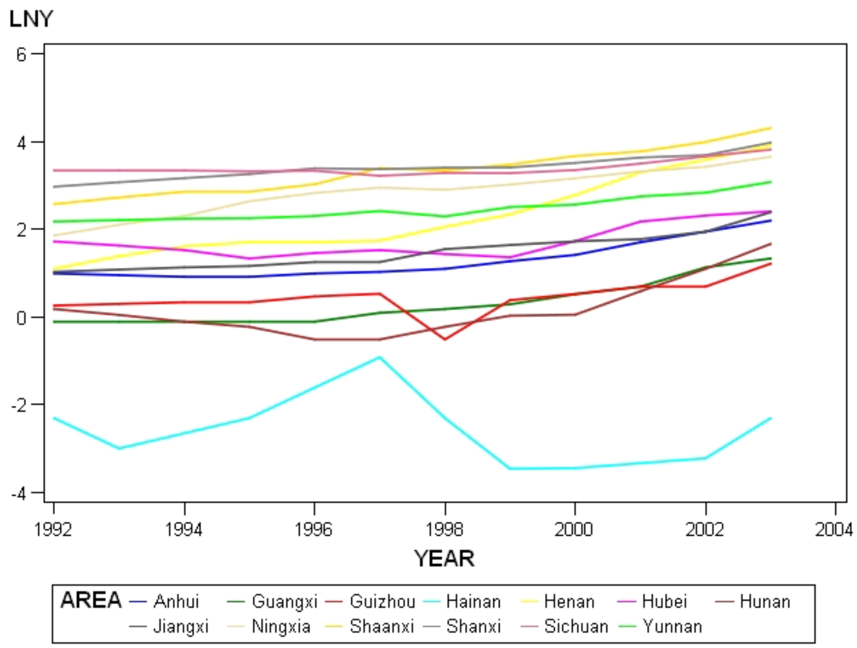


Figure 4.4: Region 3 Cow Milk Output

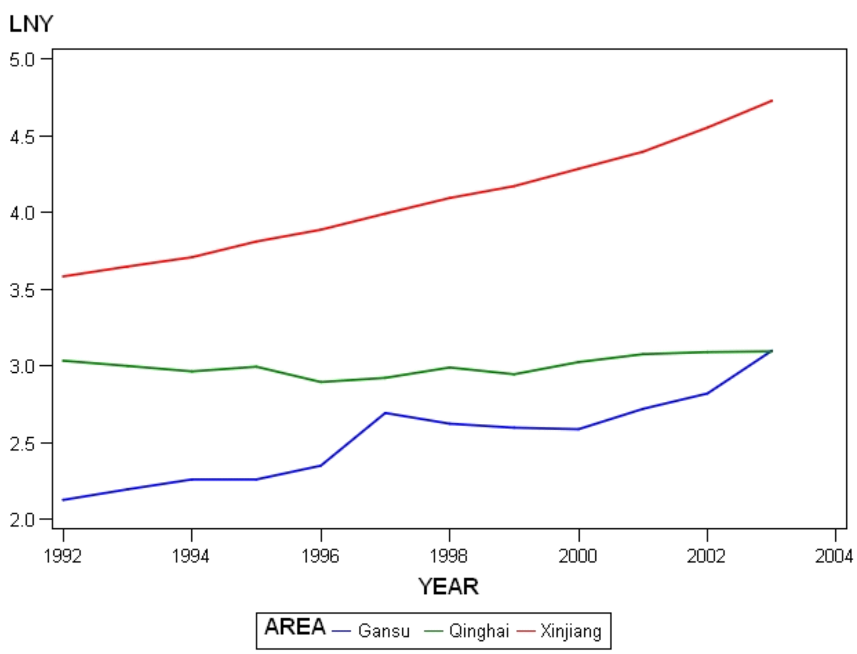


Figure 4.5: Region 4 Cow Milk Output

Many researches have expanded Nerlove model, especially in price variables. Hossein and Cummings[2] point out that milk price and feed price are correlated over time. The milk price to feed cost ratio is a simple proxy for profitability and milk/feed price ratio indicates how important the relative changes in feed and milk price are. Thus, besides proxy dairy product price index, we will include feeding stock price index (F_t) in our functional forms. From constructive forms usually used in milk production literature, we could see that the number of cows N_t is playing important role in output. Given certain yield level per cow, the only way to expand total milk output is to increase the number of cows. Thus, we will expand Nerlove model into Equation (4.5) and we will have static constructive reduced form of production in Equation (4.6). We will apply Equation (4.5) for Region 1 and 2, and apply Equation (4.6) for Regions 3 and 4, given their output data characteristics.

$$\ln Y_t = \pi_0 + \pi_1 \ln P_{t-1} + \pi_2 \ln Y_{t-1} + \pi_3 \ln F_{t-1} + \pi_4 \ln N_t + Dummy^* + \upsilon_t \tag{4.5}$$

$$\ln Y_t = \pi_0 + \pi_1 \ln P_t + \pi_2 \ln F_t + \pi_3 \ln N_t + Dummy^* + \upsilon_t \tag{4.6}$$

where (Y_t)is total milk output of year t,(Y_{t-1}) is milk output of last year,(P_{t-1}) is milk price (retail price index as proxy) of year t-1,(N_t) is number of cows, (F_t) is feeding stock price of year t.

As we have mentioned earlier, the number of cows is a function of milk prices and other price shifters. It shall be part of price elasticity in above equations. However, Chins's milk production, especially those around metropolitan areas, used to be planned and subsidized by Chinese government. This will be discussed in detail in Chapter 5. For example, those large scale dairy farms in Region2, they were built under government support in both funding and technology. Government subsidized in their enlargement in scale, by sending imported cows to this region. Number of cows may not reflect economic theory, and may not have positive relations with milk prices. On the other hand, our price (retail dairy products price index) is a proxy of farm gate milk price. Thus our price and number of cows might not have close positive relationship as they should be. We will try our best to catch up relations between herd size and retail dairy products prices, by examing a simple static functional forme as below, instead of using correspondent dynamic forms. At the same time, in order to take care of government policy shocks, we will use a time trend year in our following functional forms.

$$\ln N_t = \alpha_0 + \alpha_1 \ln P_t + \alpha_2 year + \alpha_3 Dummy^* + \upsilon_t \tag{4.7}$$

If they do have positive relations with milk prices, then we shall include it in the Equation (4.5), and the price elasticity shall be $(\pi_1 + \pi_4\alpha_1)$. In the Equation (4.6), it will be $(\pi_1 + \pi_3\alpha_1)$.

We run OLS for Equation (4.5),Equation (4.6)and Equation (4.7), test for heterodasticity and autocorrelation by using Breusch-Pagan / Cook-Weisberg test, and Durbin-Watson tests. The results are shown in Appendix B. The results show that only Region 1's number of dairy cows have positive and significant relations with milk prices. We will use it in our calculation of price elasticity as$(\pi_1 + \pi_4\alpha_1)$. The following table list coefficients deriving from regression results (Table B.3, Table B.4, Table B.8, Table B.14 and Table B.18) after correction of autocorrelation and heterodasticity.

Table 4.1: Coefficient values used in Equation 4.5, 4.6 and 4.7

Equation 4.5	Region1	Region2
$\ln Y_{t-1}$	.5410966	.7981483
$\ln P_{t-1}$	1.421511	.2428578
$\ln F_{t-1}$	-.8029053	-.1161171
$\ln N_t$	.1427327	.2611884

Equation 4.6	Region3	Region4
$\ln P_t$	1.420753	.5499467
$\ln F_t$	-.61273	-.5195424
$\ln N_t$	.1495425	.8432921

Equation 4.7	Region1
$\ln P_t$	1.022441
year	.0048816

Region1's short run price elasticity will be $(\pi_1 + \pi_4\alpha_1)$, Region 2, 3, and 4's short run price elasticity will be(π_1).

Since we used dynamic production function for Region 1 and 2, we could derive long run price elasticity for production by dividing the short run price elasticity with $(1 - \pi_2)$.

4.3 Results and Implications

We use OLS regression to estimate the Equations (4.5) and (4.7). After test and correct heterodasticity and autocorrelation (shown in Appendix B), we have the following price elasticity results in Table 4.2.

Table 4.2: Regional Supply Price Elasticities

Regions	**Region 1**	**Region 2**	**Region 3**	**Region 4**
Supply Price Elasticity	1.57	0.79	1.42	0.55

We expect Region 1 will be more price elastic than others. Region 1, however, includes Inner Mongolia, Hebei and Heilongjiang, that are more abundant with land, especially grassland, and cheaper labors. The milk resources in this region also include high proportion of small household production. In case of milk price drop down, small dairy farms may keep the milk for self consumption, or slaughter them as sources for meet. Thus Region 1 has most elastic price responses. The dairy farms in Region 2 are close to cities and limited in fixed inputs like lands, thus they are more concentrated and more dependent on advanced machines and commercial feeding stock. They produce milk for sale, and there are not so much other choices for them to do with these cows in case of price drop. With geographic advantages, or closeness to strong demanding areas such as metro cities and urban areas, Region 2 will not respond to a price drop as dramatic as Region 1 may do. Region4 is like a self sufficient circle. They do not have too much access to imports nor do they expend a lot on dairy products, and their production is limited by their high latitude locations. The higher price will not stimulate producers that much. Region3 has limited lands, and has certain city citizens to feed. When price of dairy products go up, producers have more incentive to use land for dairy than for other agricultural products.

We shall also notice that coefficient for number of cows are comparatively small compared with coefficient for lagged output or prices. This proves our forecasts. That is, many local government subsidize local producers with cows by directly importing from countries such as Australia and Canada. Government policy intervention is a big influence here. Thus milk output has limited relations with number of cows.

When we derive long run price elasticity, we expect that with every factor of production variable, long run price elasticity will be more elastic than short run ones. Region 1 has the most elastic price response in short run or when at least one factor in production is fixed. Region 2 is inelastic in short run. However, when every thing in production is variable or in long run,Region 2 is more price elastic than Region 1. The log run results further proved our division of regions. They cater to their own regional characteristics. For example, if prices of dairy products go up this year, given we have some fixed production inputs such as lands, ranch abundant Region 1 could respond more in increasing their production compared with Metropolitan Region 2. In long run, Region 2 has more capital, technology and market access, they will be able to respond to price changes as much as Region 1 will do.

CHAPTER 5

INTERREGIONAL AND INTERNATIONAL DAIRY TRADE

In this chapter, we will first discuss China's dairy trade policy history, its changes with WTO accession, and a number of other recently emerged problems that call attention from both government and industry. We will discuss current literatures and their results on the impact of dairy trade liberalization in China. Different from their homogeneous treatment of China as a whole unit, we will adopt regional analysis, and show how our results will be different from these literatures, and how our regional results would be used for future policy and investment resources. In order to achieve these quantitative regional results, we will explore appropriate economic framework to analyze free trade policy impacts on regional dairy markets in China, specifically, the impacts on producers, and consumers' welfare, and production quantities under free trade policies. Dairy products have their own production, marketing and consumption characteristics. We will therefore begin the general economic framework reviews, we should also expect to cover the recent literatures on dairy markets models and welfare analysis. We will then describe our own partial equilibrium framework, and provide our results.

Similar to most literatures about agricultural trade policy welfare analysis, partial equilibrium was used in our model. Different from treating China as a homogeneous country, we included 4 regions of China in our modeling. Although they all face the same tariff in importing dairy products, their respective demand and supply responses to prices are different, as we have concluded in the first chapters. We shall expect different impacts to different regional producers and consumers with the same reduction in importing tariffs. We will explore free dairy trade policy's impact to different regions in China. That is, we focus more on regional welfare changes within China instead of treating China as a homogeneous country. We expect our detailed regional results to be helpful for producers/exporters and government policy makers in their investment or policy-making decisions. We will compare our results with some of the literature results in the last part of this chapter.

5.1 China Dairy Trade Policies and Evolution in Dairy Markets

Peng and Cox[20] describes dairy industries around the world as one of the most distorted agricultural sectors. In order to solve the issue of trade distortion and to promote trade liberalization of dairy products, GATT concluded the Uruguay Round Agreements in late 1993 after eight years of negotiations. In part of the agreement, GATT/WTO Agreement on Agriculture (AOA) requires all GATT members to commit on reducing domestic support, market access, and export subsidy. The commitment would be fulfilled by developed countries at the end of 2000 and by developing countries at the end of 2004. 1986-1988 is the base period for reduction.

China, Japan, Thailand, South Korea, Singapore, Philippines, Malaysia, Indonesia and India are the main dairy products producers and consumers in Asia according to Peng and Cox[20]. Different from other main Asian countries, China does not have domestic support and export subsidy policies in its dairy sectors, however, China does have tariff posed on imported dairy products as market access barriers.

Dairy trade, as part of international agricultural products trading conducted between China and the rest of world, definitely will be influenced by China's general foreign trade policy. China's general trade policy, and specifically its tariffs structure have been determined largely by the priorities in the nation's political and economical agenda[7]. China's trade policy experienced 3 stages, closed door policy (1949-1978), open door policy (1978-2000), and current WTO member (2001-present)[7]. These stages have direct impact on dairy trade tariffs and quotas. In return, the impacts of these policies were reflected on the trade volumes. With more openness to the world, Chinese people have more access to dairy products and China's dairy industry evoluted to cater to these changes in demand. The continuous changes in supply and demand also reflected in dairy trade volumes every year. In the following section, we will describe at these three different stages, what are China's general trade policy environment, its specific dairy imports tariffs or quotas, and its dairy trade volumes and dairy industry changes.

As perishable livestock products, international trade of dairy products mostly are in solid forms, such as dried milk powder and butter. As for China, milk powders are the main imported dairy products. Also, China did not have so much export in history due to its diet habits and production limits. We will demonstrate at different trade policy stages, China's main imported dairy products and their volume changes in the following sections.

5.1.1 1949-1978, Closed Door Policy

Since 1949, the newly founded People's Republic of China adopted an import-substitution or autarky strategy[7]. During this time, tariffs were used to protect

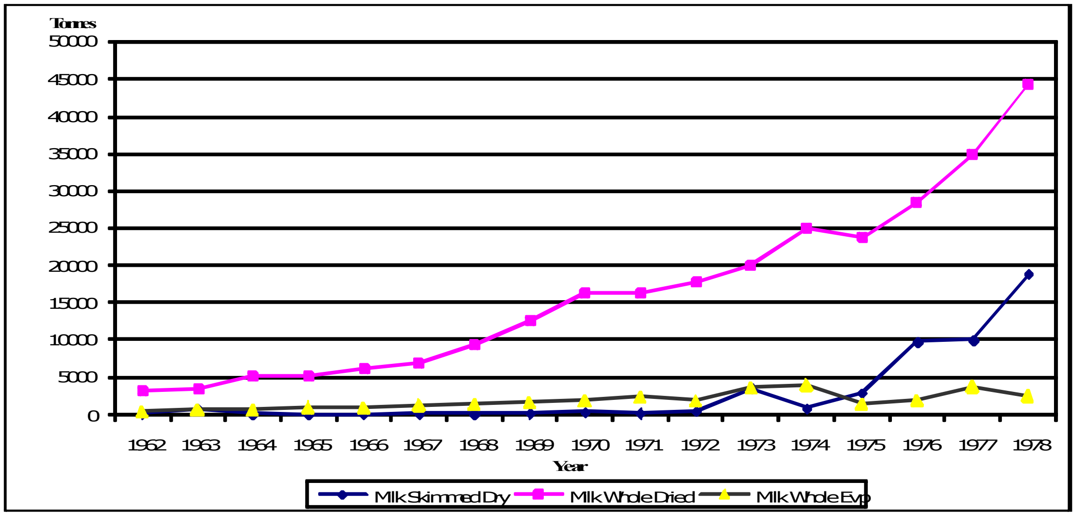


Figure 5.1: Import Dairy Products Before 1978

Sources: FAO data

infant industries in China. China's trade statistics, including its dairy trade tariffs or quotas were not traceable during these years. However, we could assume that it would be higher than those in 1990s, or higher than 30% on average. As we mentioned, China's trade policies were influenced heavily by its political agendas. Before 1990s, agricultural sectors were highly protected by high tariffs and quotas in order to fulfill self-sufficiency in agriculture production. The Food and Agricultural Organization of United Nations estimated during this period, as Figure 5.1 showed, that the main imports from China were in forms of dried whole milk powder, skimmed milk powder, and condensed whole milk. They grew rapidly in the late 1970s.

Historically, China had no dairy industry to speak of as it was an expensive product to produce and consumers could meet dietary needs more cheaply. Milk was produced for consumption in western China, where nomadic minority Chinese communities owned dual-purpose animals. Prior to 1979, some medium and large-scale producing firms owned by state or collective communities were located around larger cities to supply urban residents. Up till that time, large and medium state-owned firms were the key commercial milk suppliers to cities, while small-scale farms kept milk animals mainly for private consumption[25]. Most small-scale dairy farmers, especially the ones in the west and north, were in subsistence systems.

5.1.2 1978-2000, Open Door Policy

In December 1978, the Chinese economy was opened up, foreign investment in forms of capital or technology were embraced and welcomed in China. China also began to export its joint venture products abroad. These inflow of capital and technology served as a major stimulus to economic growth: the pre-reform rate of per capita GDP growth of 3.1 percent per year more than doubled, and has remained above 7 percent for the past two decades[1]. Corresponding to its economic reform decisions, the trade policy was then transformed towards an outward-looking and open economy[7]. In 1986, China submitted application to WTO for readmission of its membership. China significantly reduced its tariff rates in 1992 and 1996. By 1992, China reduced tariffs for 3371 items, with an average tariff reduction of 7.6%. By 1993, China cut tariffs on another 2898 items, with an average reduction of 8.8%. In 1994, the tariffs for automobiles were significantly reduced, and tariffs on cigarettes, liquors, videotapes, and buses all decreased in 1995. On April 1, 1996, China launched a major tariff reduction on 4900 items, or 76.3% of all existing tariff items. The average reduction in tariff levels was 35%, the largest by that time.[7]

Table 5.1: The Changing Structure of China's Economy, 1970 to 2000

(per cent, based on current prices)

	1970	1980	1985	1990	1995	2000
Share of GDP						
Agriculture	40	30	28	27	20	16
Industry	46	49	43	42	49	51
Services	13	21	29	31	31	33
Share of employment						
Agriculture	81	69	62	60	52	50
Industry	10	18	21	21	23	23
Services	9	13	17	19	25	27
Share of agricultural output						
Crops	82	76	69	65	58	56
Livestock	14	18	22	26	30	30
Fish	2	2	3	5	8	10
Forestry	2	4	5	4	3	4
Share of population that is rural	83	81	76	72	71	64

Source: Kim Anderson, "Agricultural and Agricultural Policies in China and India Post-Uruguay Round", July 2003

In agricultural sectors, in 1978, the farm household responsibility system, replaced collective farms with individually managed holdings. Agriculture grew rapidly from 1979 to 1984 as industries did, after mid 1980s, agricultural grew only one –third the pace of that for industry. On the other hand, industrialization boosted the incomes in the east coastal areas. As many other developing countries, China reinvested a small percent of budget in the infrastructures of rural areas at its early industrialization. Thus, rural income kept lower than those in urban areas, and agricultural GDP weight kept shrinking in total GDP as Table 5.1 showed. With more and more rural labor flooding into urban area factories and construction sites, rural employment also declined. Anderson[1] pointed out another changes in agricultural sector, that is, with higher incomes from mainly urban areas, the demand for high protein foods kept increasing. These demands have stimulated major structural changes in agriculture as farmers sensed domestic demands. Output shares from fish, and livestock products, like milk kept growing in agricultural output.

Table 5.2: Whole Milk Powder Import Average Tariff, China 1997-2008

Year	1997	1998	1999	2000	2001	2002
Percentage	30	25	25	25	25	20
Year	2003	2004	2005	2006	2007	2008
Percentage	16.67	13.33	10	10	10	10

Sources: Food and Agricultural Policy Research Institute, Iowa State University

Agricultural sectors such as grains and cotton have been regarded as strategic commodities, and their trade has been highly protected. Non-strategic products, such as dairy products, were among the first agricultural commodities that enjoyed reforms toward market-oriented economy. In 1998, dairy import tariff were also significantly reduced from 30% to 25% (Table 5.2). There is no document showing that, severe non-tariff barriers (NTBs) existed in dairy imports, such as import quotas, exchange control, and permit authorization. However, state owned trade companies were assigned to handle the imports at that time. For example, Chinese government set up China Grains and Oil Import and Export Co. to import or export commodities related with agricultural products. If dairy producers or retailers would like to import certain dairy material or commodities, they had to go through these state owned companies, or China Grains and Oil Import and Export Co. in their respective provinces. Every Provincial China Grains and Oil Import and Export Co. would then contact with foreign providers as representatives. China Grains and Oil Import and Export Co. would charge certain commissions from foreign providers. This would turn into a controlled trade between foreign providers and Chinese buyers, and the costs would be higher than if they were allowed to deal with each other freely.

From FAO data, we observe a steady increase in dairy imports, mainly in dried whole milk powder, skim milk powder and evaporated whole milk prod-

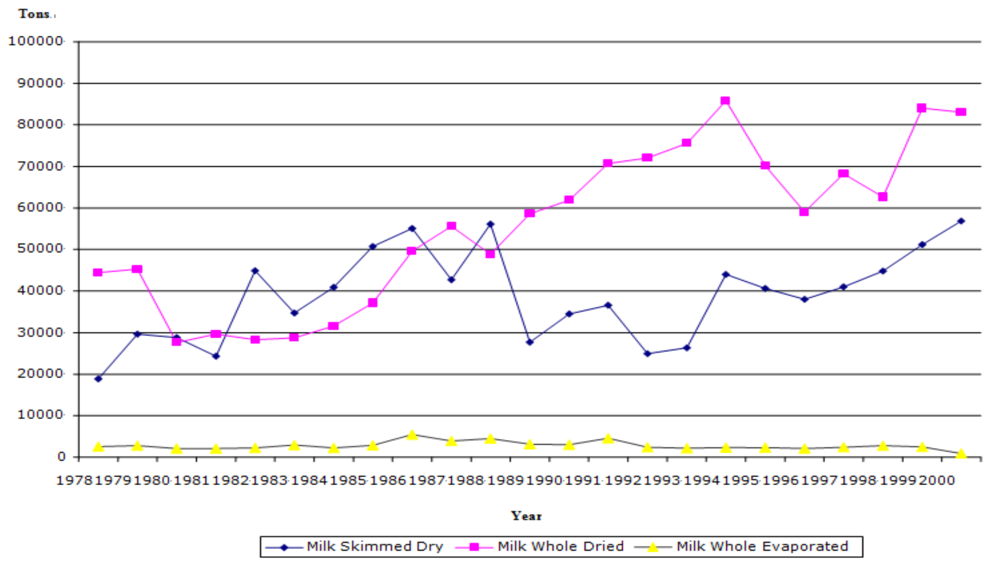


Figure 5.2: Dairy Imports 1978-2000

ucts. The sharp reduction in tariff from 1998 showed stimulus effects to the imports volumes in milk powders. At the end of 2000, whole and skim milk powder imports, all doubled those in 1978 (Figure 5.2).

In the 1980s, foreign companies and government began to invest capital and provide technology to develop China's dairy industry, in addition to multilateral organizations including the UNDP and EU. The Chinese government also provided beneficial policies for dairy farms around cities. These projects contributed to the fast increase of China's milk output[25]. Most of these projects were oriented towards the large or medium-scale dairy farms around cities, so to a certain degree, they broadened the technical gap between large producers and small households, further differentiating milk production systems. However, up until 1996, the small-scale producers dominated the total production.[26] With limited land and technology, even if production grew rapidly as we have seen in Chapter 4, the total output still cannot meet the de-

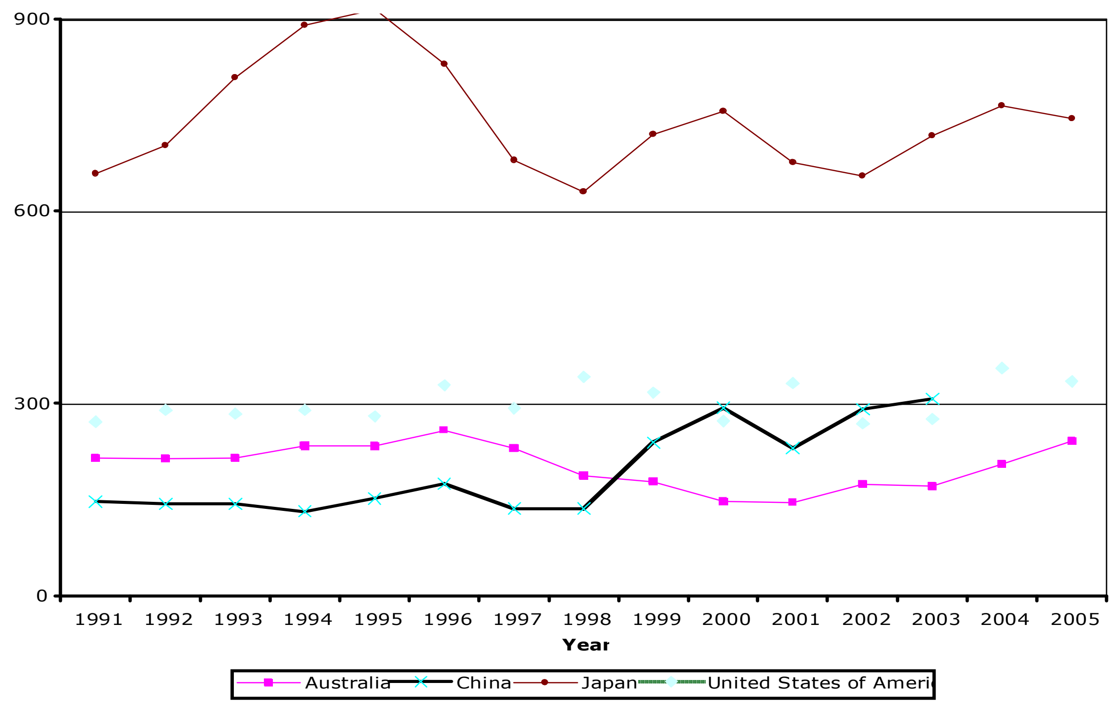


Figure 5.3: FAO Country Milk Producer Price in US Dollars

mand side.

Import is also closely connected with world milk producing prices. Figure 5.3 shows Food and Agricultural Organization's data on historic country wise milk producing prices, back as far as in 1990. We selected several main world milk producers, such as Australia and US, and producer that might be future importer from China, such as Japan. Take 1996 to 2000 for example, during this time, China's local producer price went up and at the same time, we could observe, Australia's local price was downward. This might also help explain the swing up of China's import during this period.

5.1.3 Admission to WTO, after 2001

China has taken reforms and made substantial commitments to further reform its farm sector by end-2004 [1]. China has promised no agricultural export subsidies, and limit domestic agricultural production support to 8.5% of value of its production in its WTO Protocol of Accession. China also committed that tariff rate quotas will be remained only on wheat, rice, maize, edible oils, sugar, cotton and wool. Another important reform and commitment is, state trading monopolies except for tobaccos will disappear, and state-owned trading enterprises will compete with private firms in importing and exporting of farm products. Anderson thinks that farmers and the whole rural sector will be affected by China's commitment to provide improved and WTO-bound market access for industrial products. For example, mineral and manufacturing tariffs will be bound and generally reduced on a broad basis, with many tariffs falling to 10% or less, which will provide more access to agricultural chemicals and facilities from abroad. Tariffs will be cut on accession and further cuts will be phased in by 2005 (with just a few exceptions). Also, for industrial products, China will reduce significantly its non-tariff measures and eliminate all quotas by no later than 2005. Through 1990s, the average scheduled tariff rates for manufacturing was above then fell more for agriculture, but by 2005 the manufacturing average was a simple average of 7 percent, versus 17 percent for agriculture. Thus, agriculture is comparatively more protected than manufacturing.

From Table 5.2, we can observe that tariff rate for whole dried milk powder kept falling from 25% in 2001, to 10% in 2005 and till 2008. It was lower than average agricultural tariff rate, but still higher than manufacturing part.

Reduced tariff after 2000 to some degree helped imports volumes to grow,

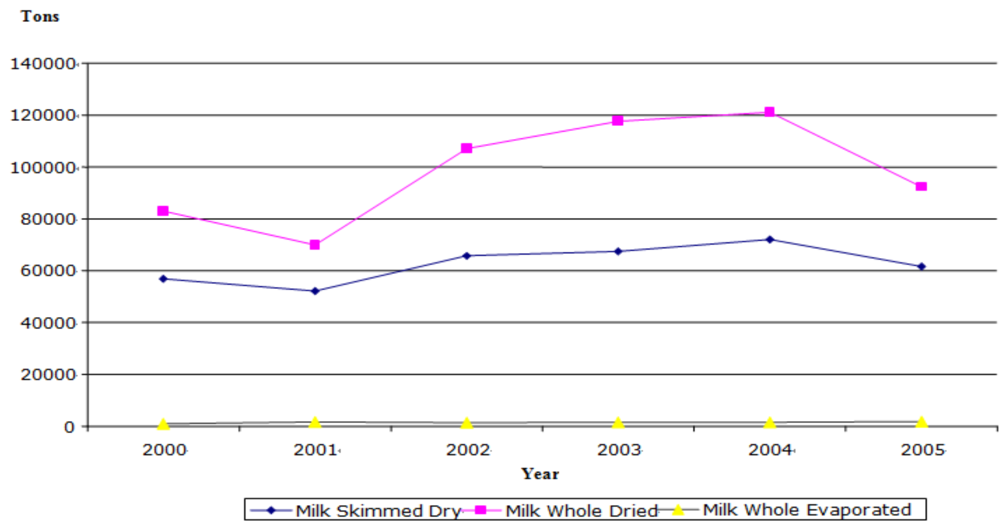


Figure 5.4: Dairy Imports 2000 to 2005, FAO data

but not so much as the effects they had in 1990s. From Figure 5.4, we could see the imports volume for the main dairy products, whole and skimmed dry milk powder was growing at a steady or fluctuating rate through 2000 to 2005. From 2001 to 2004, the lowing tariff did have some stimulating effects on import volumes. In 2005, the stimulating effects were not that obvious. The reason behind that might be explained by China's rapid growing dairy industry during that time.

After 1990, marketing reforms were carried out in China that influenced the dairy industry. Large and medium state-owned or collective owned farms evolved into large commercial dairy firms, such as Shanghai Bright. Chinese dairy consumption, especially in urban areas, kept rocketing upward beginning in the early 1990s. Preferences, enabled by incomes, also switched from condensed milk and whole milk powder consumption to a variety of dairy products, including fresh milk, yoghurts, and ice cream. Enjoying the increasing demand, suburban dairy farms merged and vertically integrated into larger scale operations covering raw milk production to supermarket sales. Most of these have been transformed into private companies. Some farm households located around the cities chose to specialize in dairy producing activities and are categorized as ”Specialized Dairy Farms”[16]. Their main activity is oriented towards commercial milk production, but they may also have other agricultural activities. These farms mainly use family labor, and some of their inputs are from the cash-crops byproducts. Recently, small–scale farms have begun to disappear in these suburban areas, and specialized dairy farms have begun to merge with large firms by contributing their cows to ”Concentration Centers”, which pool cows from many dairy farms[16]. The ownership of the cows stays with the small-scale farmers, but the process of harvesting enjoys the benefit of the larger scale provided through the ”concentration centers”. Contributors (small-scale producers) share the profits the centers in accordance with their share of cows. At the same time, small scale households in traditional milk producing areas of west and north China have started contracting with large firms, who invest and build their own dairy farms in these areas in the last 10 years. To certain degree, contracting with large firms promoted milk production commercialization from the small-holder ranch households, while enabling greater volumes processed locally. From Chapter4, we knew that after 2000, China’s milk total output increased sharply to 200 millions tones, ranked world’s number 7 in 2005. Domestic production development to some extent reduces the total amount of imports. At the same time, Figure 5.3 shows that main world milk producers’ price all went up after 2001, which raised world milk prices. The higher world price will also reduce the amount of imports.

Due to historical reasons, policy changes, domestic dairy industries developed unevenly across China. On the other hand, the demand is not even as we discussed in Chapter 2. Thus regional net demand for imports will not be the same. In the following sections, we will explore methodologies to estimate regional dairy imports trends within China.

5.2 Partial Equilibrium vs. General Equilibrium

In the economics literature, trade policy analysis has been done under two main frameworks, general equilibrium and partial equilibrium. International trade theory is fundamentally a general equilibrium affair, but there are many circumstances in which partial equilibrium modeling is both appropriate and desirable.[13] Hertel undertook two experiments, one involves liberating both food and nonfood policies, and the other involves a food-specific shock in the agricultural sector[13]. From the first experiment result, he criticized and demonstrated that partial equilibrium studies, compared with general equilibrium, may understate the impacts of simultaneous shocks to agricultural production and trades. But, the second experiment results showed that Partial Equilibrium (PE) was quite successful in predicting the changes in agricultural output. That is, "when the shock is sector-specific, PE models performs very well. The major benefits of General Equilibrium analysis is its ability to draw the link between agricultural and nonagricultural interests in trade policy", which in our case, is not a major concern.

Although applied partial equilibrium models have certain limitations by not taking into account of many factors analyzed in general equilibrium trade models, they have their own advantages. Applied partial equilibrium models focus on a set of limited factors, such as prices and policy variables, which allow applied partial equilibrium models to have relatively rapid and transparent analysis of a range of commercial policy issues. According to Francois and Reinert[11], there are two partial equilibrium models that are widely used. One is simple perfect substitute model, and the other is imperfect substitute (Armington) model. The key difference between these two models is the treatment for the imported products. The former treat imported products as perfect substitute for domestic production, while the later treat them differently. In our research, we will treat imported dairy products as perfect substitute for domestic products when they are converted into raw milk, due to limited data availability.

The most recent partial equilibrium analysis that addresses China's dairy sector under free trade scenarios is written by Peng and Cox[20]. In their paper, Peng and Cox used a world dairy model, the UW-Madison World Dairy Model (UW-WDM) which reflects both vertical and spatial characteristics of dairy sector. The same methodology was also used by Zhu, Chavas and Cox[9], which does not include China as one of the analysis objectives. The UW-WDM model is not publicly published to show its equilibrium framework. Still, many institutions and government agencies, such as US Department of Agriculture, use it for world dairy marketing researches.

The UW-WDM model, as a global dairy model, claims that it is a hedonic, spatial equilibrium with multi-component formulation for raw milk component distribution covering 21 regions in the world. The vertical characteristics include the processing of farm milk components into many different dairy products. They concluded that five types of farm milk (cow, buffalo, camel, sheep and goat) with 4 milk components (milk fat, casein, whey protein and lactose)

Table 5.3: WTO 2007/Asia Liberalization Results for China

	Change from Base (million US $)	
Country	**Consumer Surplus**	**Producer Surplus**
China	120	-33

Sources: Peng and Cox *"An Economic Analysis of the Impacts of Trade Liberalization on Asian Dairy Market"*[20]

could be processed into eight dairy products (cheese, butter, whole milk powder (WMP), skim milk powder (SMP), dry whey, casein, evaporated/condensed milk, and other dairy products). They claimed that they covered spatial characteristics including the distribution of milk production, demand, and trade for dairy products in different regions of the world.

Based on data collected from FAO, FAPRI and OECD, Peng and Cox checked both domestic and trade policies changes and derived how trade liberalization will likely to affect farm milk price, dairy production, consumption and trade, and consumer and producer surplus in Asian countries. These trade scenarios include WTO 2007/Japan no Domestic Subsidy, WTO 2007/Other Asia No Tariff &TRQs, WTO 2007/Asia Liberalization and WTO 2007/World Liberalization. The model assumes intermediate run (3-5 years) supply /demand responses, where supply is shifted by 5 years moving average growth rates, and demand is shifted by regional GDP/population growth. Then, they solve for regional production, consumption and trade of milk and dairy products that maximizes producer and consumer welfare net of processing and transport costs in Year 2007, using Year 2002 as the base year.

Table 5.3 summarizes the results for WTO 2007/Asia Liberalization.

5.3 Dairy Market Levels and Dairy Product Characteristics

There are several studies described the dairy market structures and dairy products' characteristics. These studies mainly are from professional dairy marketing research groups, such as Cornell Program on Dairy Markets and Policy. Dairy market typically has vertical market levels, as Figure 2.4 has described. With its raw milk production scattered geographically, spatial factors are important in determining the supply to each market levels. Due to its joint-inputs, multi-outputs characteristics, it is crucial to choose correct method to convert final products into original raw milk.

For example, Bishop[4] has described U.S. dairy market structure as that the primary product milk is produced on geographically dispersed farms. It must be transported to processing facilities, then it is transformed into intermediate and final consumer products. A critical point is that at least three market level representations are essential to the analysis of the market. Novakovic[19] has divided the market into three vertical levels: retail, wholesale and farm level, as shown in Figure 2.4. Bishop adopted the same division and further explained the features of dairy products on each level.

At the production level, one of the most important characteristics is that milk is not homogenous commodity. The compositions of the raw milk, which are the key material for processing into intermediate products, vary in response to a range of factors: types of feed, breed of cow, and stage of lactation being the most important.

There are five types of processing facilities respectively corresponding to the five classes of products to be consumed; they are fluid milk, soft products, cheese (exclude cottage cheese), butter and anhydrous milk fat, and milk powder (plus condensed and evaporated milk). Soft products include yoghurt, ice cream, and cottage cheese. The beverage milk's processing procedure requires simple steps as standardizing the composition, pasteurizing and then packaging. A more complicated physical transformation is needed to produce products such as cheese, butter. The general procedure contains separating milk components, then transforming or recombining into desired product forms.

The supply of milk components is allocated to the multitude of uses for those components during the processing sector. At this processing level, interplant movements of milk and milk products are of important role in balancing. Interplant movements could be in form of raw milk, or intermediate products which have transformed to some degree at the plant of first receipt. Bishop gave some examples that help understanding the complexity of this market level, for example, a fluid plant may have a surplus of milk fat, thus it would ship the cream away, most likely to a butter plant.

A distribution system would connect the processing level with the final consume level. Under an informal arrangement, for example, in India the milk was delivered and distributed by the milk farmers directly to consumers or retail stores. While under a formal system, finished products are transported from processing plants either directly to retail stores (especially for perishable products, such as fluid milk), or to some kind of warehousing systems, where they are redistributed to consumers.

International trade mostly happen among intermediate products from processing level or among final products. Many trade models are built to analyze the future trade flows in dairy products, such as Cox's UW-Madison World

Dairy Model. Different dairy products utilize milk components in different proportions. For instance, butter is mainly composed of fat and few other milk solids while Nonfat Dry Milk (NDM) contains practically no fat but proteins and carbohydrates. Because of the complexity rooting from milk processing, some studies have used homogeneous measurements in computing milk used in these trades; the most used is the method ”milk fat based milk equivalent”. Bishop, Pratt and Novakovic[5] have criticized this methodology. They used an example to illustrate how this milk equivalents method, although make the problem more tractable, would impose unrealistic restrictions on the process of allocating milk to the various products produced from milk, thus may understate or overstate the actual milk needed. A good example from the paper is that given raw milk supply constant, and four products, butter, NDM, cheese and fluid milk are going to be produced. If the demand for NDM goes up, the model must allocate milk away from one of the other three products. The NDM's milk fat equivalent is very small, thus the models built on the methodology of single component formulation would grossly understate the milk reallocated. More importantly, many dairy products are actually joint produced [5]. When the production of butter increase, the nonfat milk solids supply will go up; when fluid milk production increase, more cream will be produced. In addition to the mis-allocation problem, the single component formulation also would assign incorrect values to milk and milk products. The value of milk components is a signaling device allowing producers to respond to the changing preferences of consumers. In most developed countries, per capita consumption of fat-intensive dairy products has declined. Hence the fat component became comparatively less valued compared with the nonfat components. In order to express the diverging component valuations, a multiple component formulation is essential.

Different from United States, China's market lacks these essential data for multiple component formulation. We bear this limitation in mind, and take the fat component methods in transferring five groups of dairy products: fluid milk, soft products, cheese (exclude cottage cheese), butter and anhydrous milk fat, and milk powder (plus condensed and evaporated milk) into raw milk.

5.4 China Regional Dairy Markets Partial Equilibrium Models

5.4.1 Regional Partial Equilibrium Model

There are many ways to build up a partial equilibrium trade model for a commodity. Since dairy products markets are a combination of spatially dispersed raw milk production with vertical markets, it is important to explore models compatible with these two features. And in fact, many studies have adopted spatial equilibrium model as the basic economic framework under which they conduct partial equilibrium comparative analysis to predict the trade flows and macro welfare changes to each country. For example, Peng and Cox[20] predicted what dairy trade liberalization would impact highly protective countries in Asia, such as Korea and Japan.

Facing spatial and vertical characteristics of dairy markets, together with data limitation, we will build a partial equilibrium to estimate free trade policies' impact to different regions in China. In the following model, we will address spatial characteristic by dividing China's production and consumption regions into 4 groups; and we will respond to the vertical characteristic by converting consumption of dairy products into raw milk.

We will follow a perfect substitutes applied partial equilibrium framework, assuming imported and domestic dairy products are homogeneous goods, thus imports are perfect substitutes for domestic production. Assuming that elasticities are constant, Francois and Reinert [11] have proposed that a country's trade could be composed of:

Regional demand: $Q^D = Q^D(P) = K^D(P)^{\eta^D}$

Regional supply: $Q^S = Q^S(P) = K^S(P)^{\varepsilon^S}$

Price equation: $p^*(1 + t) = P$

Where t refers to tariff wedge, the after tariff price P is a function of world price p and t. Q^D refers to total demand from this country, which is a function of prevailing price after tariff t in this country. Q^S refers to total supply from this country, which is a function of price P in equilibrium. K^D, K^S are constants, ε and η are elasticities for demand and supply. We will apply these basic concepts into our four regional models.

$$Q_i^D = K_i^D P_i^{\eta_i^D} \tag{5.1}$$

$$Q_i^S = K_i^S P_i^{\varepsilon_i^S} \tag{5.2}$$

$$p_i^*(1 + t) = P_i \tag{5.3}$$

where $i = Region 1, 2, 3, and 4$.

5.4.2 Welfare Analysis Procedure

Before we conduct any regional welfare analysis, we check data availability, and describe how we derived our welfare change results for respective regional producers and consumers.

Consumption Converted in Raw Milk

We use year 2004 as our data baseline to predict the welfare changes under free trade policies. In this data baseline, we have regional raw milk production Q_i^S, we have derived η_i^D (Table 3.2)and ε_i^S (Table 4.2)in Chapter 3 and Chapter 4 from consumption and production equilibriums. We also have 2004 regional price index for dairy products as proxy for producer prices. Following Equation (5.1), (5.2) , we would need Q_i^D to constant variables K_i^D and K_i^S; in (5.3), we need to find out based on raw milk, what is tariff t.

With very little export, for a country or region, $Q_i^D = Q_i^S + Q_i^I$, where Q_i^Irefers regional imports. We have mentioned that we will convert all dairy products into raw milk, following fat content standards. From trade data published in Food and Agricultural Organization (FAO) website, we have 2004 China's total imports in kg for five classes of dairy products, fluid milk, "soft products", cheese (exclude cottage cheese), butter and anhydrous milk fat, and milk powder(plus condensed and evaporated milk). In 2004's China Dairy Yearbook, we could have import quantity of above products detailed in provinces. From both

Table 5.4: China's Major Dairy Products Import Tariff in Percentage

Tariff Heading	Description	China
401	Milk and cream	23.67
402	Milk and cream, concentrated or containing added sugar	32.6
403	Buttermilk, curdled milk and cream, yogurt	43
404	Whey	25
405	Butter and other fats and oils derived from milk; dairy spreads	44
406	Cheese and curd	43.2

Sources: APEC data, Peng and Cox[20]

resources, we could have total China raw milk import equivalent quantity calculated and assigned into 4 regions, that is Q_i^D. Then following Equation (5.1), (5.2) we derive constant variables K_i^D and K_i^S.

Tariff in Raw Milk Conversion

Based on Equation (5.3), the price changes will be forecasted by the reduction in tariff. With known P and t from current data from FAO, we could derive p for world price that China face. If we know the size of t, we could calculate a new P through Equation (5.3). Since we converted all imports quantities into raw milk, it would be reasonable to covert different dairy products import tariff into weighted raw milk base. That is, we estimated how many units of dairy products were imported in 2004, converted them into raw milk, and calculated their weights of raw milk over total the sum of converted raw milk. Based on the import tariff information shown in Table 5.4, we derive 25% tariff rate for China's dairy products in raw milk base.

Policy Experiment Scenario

According to Table 5.2, Chinese dairy tariff has been reduced from 30 percent to 10 percent in 2008. From what Chinese government promised when entering WTO, China is moving towards tariff free scenario in its trade with other countries. Peng and Cox [20] also used tariff free scenario as the experiment for their dairy trade analysis in Asian countries. We will adopt zero tariff scenarios in our analysis. On one hand, it is widely used in literatures to do welfare analysis; on the other hand, it is a reasonable scenario in near future according to the current trend in dairy trade.

Welfare Change Calculation and Results

From Equation (5.1) to (5.3), we have Consumer Welfare Changes equal to: $\int_p^P Q_i^D(x)dx$, which is shown as area $A + B + C + D$ in Figure 5.5. If we assume the demand function $Q_i^D(\cdot)$ is linear, we can simplify the Consumer Welfare Changes as $(Q_i^D(P) + Q_i^D(p))(P - p)/2$, where $Q_i^D(p)$ is the new consumption level after tariff reduction. Meanwhile, the Producer Welfare Changes equal to area $D = \int_p^P Q_i^S(x)dx$, which can be approximated as $(Q_i^S(P) + Q_i^S(p))(P - p)/2$, where $Q_i^S(p)$ is the new production level after tariff reduction.

Triangle $A + C$ is commonly referred to as a welfare triangle. It would be the consumer welfare changes $(A + B + C + D)$ producer minus the welfare changes D and minus the government tariff revenue loss B. Area B equal to $(Q_i^D(P) - Q_i^S(P))(P - p)$.

Table 5.5 summarizes the changes in regional raw milk production and consumption, if the government reduces the tariff to zero. Table 5.6 summarizes the

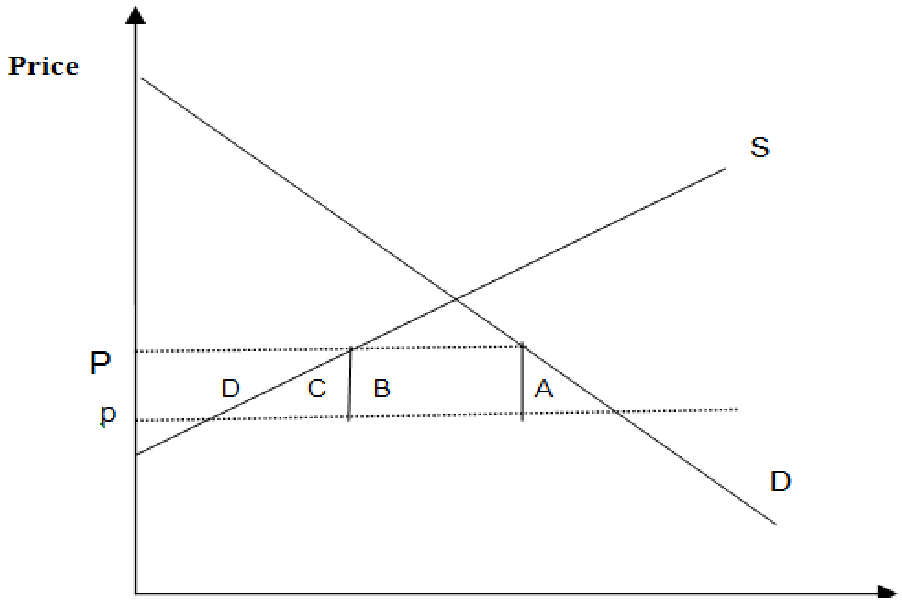


Figure 5.5: Welfare Triangels

Table 5.5: Consumption and Production Changes in Raw Milk

		Change in Percentage
Region 1	**Production**	-39.3%
	Consumption	19%
Region 2	**Production**	-20%
	Consumption	15.8%
Region 3	**Production**	- 35.5%
	Consumption	23.8%
Region 4	**Production**	-13.75%
	Consumption	27.5%

corresponding welfare changes in these 4 regions.

Table 5.6: Regional Welfare Changes Comparison

		Change in Millions of RMB
Region 1	Consumer	264.8
	Producer	-92.6
	Total Regional Welfare	45.7
Region 2	Consumer	1506
	Producer	-32.81
	Total Regional Welfare	111
Region 3	Consumer	97.8
	Producer	-19.2
	Total Regional Welfare	14.5
Region 4	Consumer	38.7
	Producer	-26.8
	Total Regional Welfare	6.7

Table 5.7: Regional Dairy Products Net Imports Converted into Milk in Metric Tons

Region	Net Import 2004	Net Import Projected	Net Changes
Region 1	293666	506039	212372
Region 2	2908622	3383693	475070
Region 3	127432	185289	57857
Region 4	9733	34039	24305

5.5 Regional Results and Comparison With Recent Research Results

In this section, we will present our results. We will compare our results with both our expectations and with recent literature findings.

As we have concluded in Chapter 2, 3 and 4, we divided China into 4 regions, each of which has different stories in production and consumption of milk and dairy products due to demographic and natural resources differences. Producers and consumers' welfare changes are influenced by producers and consumers' responses to prices and volume of production and consumption changes. When we predict which region will be the largest importer of dairy products, it not only depends on production and consumption potentials, such as population, income, etc, but also connected with its base volume of trade before free trade policy. In general, our results meet our expectations for these 4 different regions.

Milk production in Northern and Northeast China (Region 1) uses more traditional methods to serve nearby metropolitan demand and local demand from minority diet. Producers are more sensitive to price changes, but their local consumers are less price elastic due to their minority diet habits. If the prices for dairy products go down with the reduction of tariff, the reduced farm gate prices will drive producers, especially small scale household producers to switch from milk production. The local minority residents' dairy diet, which is already their necessary daily consumption, will not be enhanced by the price reduction that much. Their producers will suffer most, which is as our results showed in Table 5.6.

Eastern Coast China (Region 2) is the richest area in China, and its milk production is mostly used to meet rising demand in metro areas, and its production elasticity is the least. Facing price reduction, with huge metropolitan demand as backup, its production may not suffer as much as Region 1. Its consumers, who enjoyed one of the highest per capita dairy consumption, may not be so sensitive to price reduction and increase consumption that much. However with the

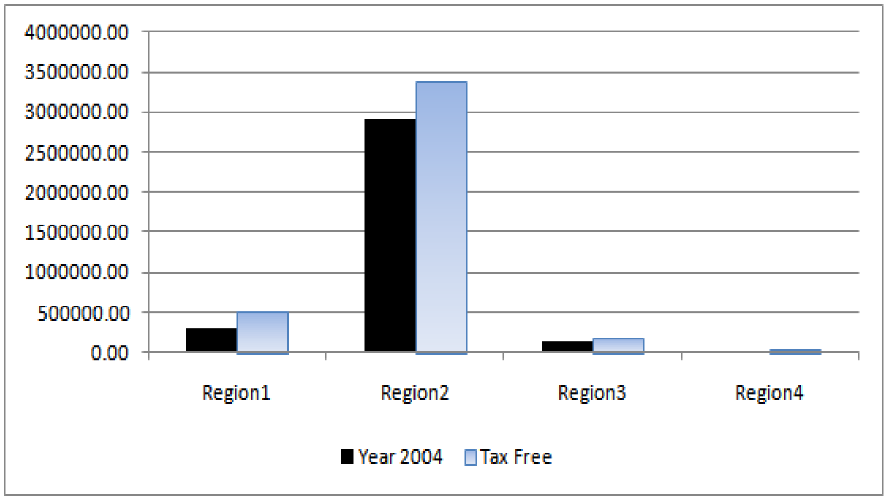


Figure 5.6: Regional net dairy imports converted in milk (metric tons) 2004 and regional net imports changes after tax free policy

largest consumption volume, we still expect a significant gain in consumption. Our results show it is ranked Number 1 in consumer welfare gains. Region 2 is currently the largest net importer in China (Figure 5.6 and Table 5.7). With price reduction, its import is expected to increase. We expect this region continue to be the largest importer among the four regions based on its current import volume.

Inland China Region 3 and Region 4 is less price elastic in production compared with Region 1, but more price elastic than Region 2, for they have no that big cities to back up their production and they have limited land. With lower income than Region 2, and nearly no traditions in dairy diet as those in Region 1, the consumers are more price-responsive than those in Region 1 and Region 2. We have discussed in Chapter 2, 3 and 4 that their low income may lead to their low dairy consumption. With price reduction, their consumers will increase their dairy consumption more significantly than Region 2 (Table 5.5). We expect these regions may gain more from price reduction, and that is what our results show. The price reduction after free dairy trade policy will stimulate the imports in Region 3 and 4 (Table 5.7 and Figure 5.6). Due to their low importing base, which, as we explained in former chapters, is caused by their low income levels, lack of dairy diet habits and inland inconvenient geographic locations for imports their new level of imports still could not be compared with Region 2 and we do not expect they would exceed Region 2 as main importing regions.

Comparing our results with the recent literature findings of Peng and Cox[20],our within-China multi-regional dairy model has the following advantages.

First, we are much more detailed into regional dairy production and consumption division in China than [20].Our focus of research is China's dairy market. We divide China's market into 4 different regions according to demographic and economic factors to show hedonic and spatial characteristics. Our division was also tested by deriving significantly different production and consumption responses.

Second, we are more consistent in model building. Our regional supply and demand responses are derived from time series data of production, consumption, prices and income, published by China's statistical bureau. Using year 2004 as the base year and the scenario year, we calculated that under the free trade scenario, that is, China reduces its tariff to zero, how consumer and producer welfare changes. We only use FAO import and export data for trade calculation. While Peng and Cox used existing elasticities from FAO, FAPRI and OECD.

Third, our results are much easier to read for industry and policy makers. Instead of telling a story for a whole country, our results show readers which area's consumers are more sensitive to price increase, or which area's producers are more happy with price increase. This will provide them a detailed information in a country for their strategic business or policy decisions.

However, we could still find that our results show same trends in consumer and producer surplus as the results in [20]. Comparing Table 5.3 with Table 5.6, both table show that aggregate consumer surplus is positive, and producer surplus is negative. However, our results clearly tell which region's consumer and producer gain/lose the most. This provides useful information in market decision-making and policy designation. We will further explore these implications in the next concluding Chapter 6.

CHAPTER 6

CONCLUSION

Insights about the status and implications for the Chinese dairy sector can be obtained in three distinct areas.

For empirical analysts, the characteristics and performance of alternative techniques to estimate market and trade effects are illuminated, given the limited data constraints.

For sector participants and economic planners, there are implications for market opportunities within China as well as global export opportunities.

From the perspective of Chinese policy-makers, there are implications for internal agricultural economic development and consumer food availability, safety, and trade.

From the perspective of the analytical modeler, the typical tradeoff implied by partial equilibrium vs. general equilibrium analysis is that of intra-sectoral detail vs. inter-sector interactions, especially in competition for common inputs or share of consumer expenditure. This paper attempts to bring together the benefits of both approaches by utilizing a multi-sector partial equilibrium model in conjunction with a geographically disaggregated model of one agri-food sector in a spatial large and economically diverse country. This approach needs further refinement, but it shows promise for providing far more complete insights into both interregional nuances as well as net trade opportunities for China as a whole. It creates an opportunity for an outcome that includes both production and import of dairy products.

6.1 Summary

6.1.1 Research Questions

Our research questions focus on where and to what extent will milk production and dairy product consumption grow within China, and what are the implications for interregional and international marketing opportunities and policies. In order to analyze this question, we divide China into four regions according to demographic and geographic characteristics, i.e. economic development, dietary habits and agricultural production features. Linear regressions estimate regional production and consumption responses within China. Under a free trade scenario, China's regional dairy products production and consumption changes are estimated.

6.1.2 Results

Each of the four regions of China has a different story for farm milk production and consumption of dairy products. Milk production in northern and northeastern China (Region 1) 1) relies on more traditional methods, 2) is relatively low cost due to the low opportunity cost of land and labor, and 3) is mostly destined to serve local and nearby metropolitan demand. If future prices for dairy products go down as tariffs are reduced, the reduced farm gate prices will drive producers, especially small scale household producers, to switch from milk production to more profitable uses of their land and labor; however, many parts of this region are far better suited to livestock agriculture, as opposed to feed grains or other crops. Given Region 1's natural agronomic advantage for milk production, producers there are generally more disadvantaged by a reduction in price - their next best use of land and labor is not nearly as appealing. Compared to other regions, producers in region 1 would experience the largest decline in milk production, both in relative and absolute terms. Consumers would enjoy price declines, but the welfare benefits to them are less than in the more urban, eastern China region. This region relies more heavily on local production and would likely have less easy access to imports than the other coastal provinces to the south.

Inland China (region 3) has relatively higher production costs than Region1. Its per capita and total demand is less than Eastern China (Region2), which has both higher average household income and population. It is estimated that consumers in Region 3 will increase consumption more in response to a price reduction than occurs in Region 1 or 2. Producers, who tend to be smaller than in Region 2, reduce production by a relative amount only slightly less than the change in Region 1. Inland China is an area with many agronomically appealing options, including wheat to the north and rice to the south. At present, it is not at all clear that milk production is the best use for this region's agricultural resources, much less for future growth. The southern portion of the region is warm and humid, making it especially ill-suited to milk production. At the same time, it is geographically the most appealing location for exports from nearby New Zealand and Australia as well as interregional shipments from northern China.

Eastern China (Region 2), with its large and relatively wealthier population, has easy access to Pacific Rim imports. Relatively inexpensive, high quality and diverse imports have been and will continue to be to be an important component of the total dairy product supply in Eastern China. Relatively modern and large farms located near the suburban fringe of the large metropolitan centers around Beijing and Shanghai are well located, both agronomically and economically, to supply urban consumer with the more perishable and fresh dairy products. Because of their larger sizes, and strong nearby demand, Region 2's producers will be somewhat buffered from reduced prices that result primarily for increased imports of more storable dairy commodities. Given that higher incomes have already led to the highest level of dairy product consumption in China, consumer consumption will not increase in percentage as much as it does in the other regions. Thus, in general, the consumer gain from free trade is not as large in relative terms. It is large in the absolute because of the very large population in this region.

Region 4 is an interesting part of China. Ethnically, it is very different from the Han population of the "middle kingdom". Spatially it is very far from the ports of the Pacific Coast and the frenetic economic development of that area. Its neighbors to the west are generally not in a position to engage in significant economic trade, either as importers or exporters. Thus, it is culturally and economically isolated from eastern and central China. The ethnic groups in this far western region have a dietary tradition of consuming dairy products that is in line with the generally favorable conditions for livestock-based production. Milk produced in this area has tended to be from sheep and goats in the more mountainous areas and yaks, camels, horses, and other species in the Steppe and grazing areas to the north. It is not uncommon for farm households to simply harvest milk for their own consumption. They have the lowest income among all the four regions. Given their limit on agricultural capacity and very low household income, consumers in Western China benefit the most from price reduction. The total social welfare gain is the highest among the four regions.

6.2 Concluding Comments

Our results provide to potential importers in or exporters to China. Different regions of this vast and diverse country have different potentials for imports and exports that derive from their characteristics as milk producers as well as dairy product consumers. Chinese policy makers can use these results to evaluate and modify their national dairy sector development policies. This may be especially propitious in the wake of the milk contamination event of late 2008[1].

6.2.1 Market Implications

Exporters or potential exporters to China may find it profitable to consider direct investment in production or processing industries in region1, in particular the provinces of Inner Mongolia, and Heilong Jiang. They are located close to the high income and high demand eastern coastal and central or Inland China regions (2 and 3). Processing and transportation facilities catering to Region 2, especially metropolitan areas such as Beijing and Tianjin could focus on urban residents' rising demand for fluid milk.

The Eastern Coastal region (2) has the most advanced processing facilities and dairy farms. They have been working hard to keep up with demand from

[1]In September 2008, "melamine-laced milk killed and sickened Chinese babies and led to recalls around the world, the routine spiking of milk with illicit substances was an open secret in China's dairy regions, according to the accounts of farmers and others with knowledge of the industry". -The Wall Street Journal, Nov. 3rd, 2008

nearby city residents. Due to limited agricultural land and hot weather in southeastern China (near Hong Kong), this area's production potential is very limited but its sales opportunities are significant, at least given the relatively high household incomes and low level of dairy proteins in their current diets. Given its convenient location to the Pacific, exporters will likely find it profitable to continue promoting whole milk powder sales in this region. Investment in processing industries such as ice cream production, a value-added food that provides both dietary diversity and pleasure, is another interesting alternative possibility.

Region 3, the Inland part of China enjoys a measure of the economic development and higher household incomes characteristic of Region 2, to the east. As such, it also has a growing demand for dairy products, although not so strong as in Region 2. Industries and investors should be more cautious and flexible in investing in locations and facilities in this region. This could be a good location for smaller scale competitors to invest in dairy farms or fluid milk and value-added processing facilities around cities. Milk powders are commonly consumed or used in food production in this region, but local facilities need to be certain that they can compete with powders shipped from nearby Australia and New Zealand.

Region 4 is located in the far western part of China. Its location is ethnically and geographical very distant from the historic Middle Kingdom and the growth and populations centers of the country. Some parts are hot tropical areas, others are mountainous, and the northern areas bordering on central Asia are vast pasturelands. Household incomes are low to very low. Some ethnic minorities have a long tradition of dairy product consumption, but the milk comes from goats, sheep and other species less commonly thought of for milk production and this milk is used primarily for home consumption. Milk powders, which are easy to transport and store, will be the most convenient commodities to promote in this area as international trade expands.

Although dairy exports are currently a very small portion of China's dairy sales or its agricultural exports, there are some opportunities given China's geographic location in Asia. Peng and Cox concluded with their UW-WDM that 1) China will not be impacted much by free dairy trade and 2) China is a potential importer in Asia but an exporter to the world. However, from Figure 5.5 we see China's historic producer price is higher than that in Australia - one of the more competitive dairy countries - but lower than that in Japan, which has a very large domestic subsidy for dairy production. Given the respective geographic locations, northeastern China is well situated to export processed dairy products to nearby higher income Asian countries such as Japan or Korea. At the same time, southeastern China may import products from Australia.

6.2.2 Policy Choices

The Chinese government plays an important role in both dairy consumption and production. The government is broadly concerned about economic growth, increased availability of food, and agricultural sector growth and development. From a consumption perspective, government policies shape the food and nutrition information environment by supporting the production and dissemination of basic scientific knowledge about the relationship between diet and health. It establishes regulatory rules for food safety and enforces those rules. Ippolito concluded in his ”How government policies shape the food and nutrition information environment” [14] that government policies do have effects in both consumer and producer behavior, and it is important to recognize the dynamic nature of the problem.

In the following section, we will discuss what our results suggest about the role of government policies in both production and consumption.

On the consumer side, the Chinese government faces both domestic and international questions and doubts about its food safety system. In 2008, the chemical melamine was found in baby formula milk powders that sickened tens of thousands of babies in China. It was later discovered that this nitrogen-containing compound was introduced into producer milk as a way to falsely elevate spectrographic tests that determine protein levels based on the nitrogen content of milk. In so doing, unscrupulous milk producers obtained higher payments for their milk by adding this cheap industrial chemical. Our modeling does not include food safety and government policy as factors, but numerous empirical studies have shown that government does have influence in consumer choices by providing public information about diet-health relationship, and regulations to guarantee food safety.[14]

Ippolito argues that diet-related information is a public good; producers will not provide such information unless it is beneficial to them. Currently, several big dairy companies use the school milk programs and dairy advertisements to promote milk consumption. This has been associated with company claims of scientific results about their brands and the addition of certain additives that differentiate their product from others. One example of dubious merit is supplemental calcium that is added in a form that has limited bioavailability. The

Chinese government wants to improve its role in supporting production of scientific knowledge of diet-health information and providing dietary advice.

On the production side, the Chinese government has been following patterns long observed in other countries. Their attention is typically devoted to modernization and growth in farm milk production in ways that mimic ”the best” production sectors but which may be systems not that well adapted to Chinese conditions and constraints. It is not at all clear that the optimal policy for China is to mimic an Australian or European dairy system, either from the perspective of the Chinese milk production sector, much less from the broader food or consumer goods sector. The release of labor for agricultural production will continue to challenge the ability of the manufacturing and services sectors to absorb it. This is already of sufficient concern that China has adopted a system to control voluntary labor migration within China. In Inner Mongolia, for example, current expensive automatic milking machines in big modern farms cost more than cows were milked with less automated system. If the released labor cannot migrate to higher paying jobs, then the substitution is of questionable value.

Our results also indicates that policies to improve transportation systems and otherwise reduce interregional transactions costs could be far more effective in utilizing favorable milk production conditions in Region1 to the benefit of their producers and consumers in region 2 and 3.

The melamine scandal shows that regulations and laws are very important in milk production and processing sectors. This goes beyond food safety concerns. Currently, there is no mandatory nutrition-labeling requirement in China. Food labeling may not only help consumer make choices, especially with respect to unfamiliar product, but it also can help producers cater to international standards of production, and prepare themselves for potential exports.

6.3 Suggestions for Further Research

To be sure, additional research is required before we can say we have a better or accurate picture of interregional trade or the prospects for dairy foods trade with other countries. There are also certain limitations or drawbacks in our methodologies and assumptions that we would like to recognize and hope for future improvement, especially as better data becomes available.

First, we conducted our research under a partial equilibrium framework. Economists have long recognized that the partial measures used in applied work are incomplete and that a general equilibrium framework is needed to capture all the interactions that determine the net relative impact of a mix of policies on the agricultural and non agricultural sectors.[3] For example, the free trade policy conducted by Chinese government may have impacts on the relative cost of labor which will in turn lead to different consequences in dairy production. As Romeo, Sherman, Finn and Peter's results demonstrated, we might have missed the actions operating through indirect product and factor market linkages.

Second, in our Almost Ideal Demand functional forms and later in building our partial equilibrium models, we assume perfect substitution between domestically produced and imported dairy products, such as milk powder. This assumption is common in Partial Equilibrium Models. We assume the law of one price holds for our price transmission from world price to domestic prices, which is empirically suspect. In Mundlak and Larson's "On the Transmission of World Agricultural Prices"[17], they conclude, " evidence for major traded agricultural commodities indicated that the price transmission elasticities were close to 1 for developed countries, although significantly lower for developing countries." In contrast, widely used Computable General Equilibrium (CGE) models normally specify that imports are imperfect substitutes for domestically produced goods. In many models, exports are also differentiated from domestically produced goods that are sold in domestic markets.

Third, more attention should be paid to our producer price. In our supply estimation, we used the retail dairy products index or consumer dairy price index as a proxy for raw milk producer prices, because there is not farm milk price reported for China. We have to acknowledge that the farm gate raw milk price and retail dairy products' price difference, or the marketing margins between farm and retail, is unlikely to be constant over time or constant across regions. Most likely it is not even a monotonic transformation. The supply chain varies across these regions. Empirically it is not possible for all these regions to have the same marketing proportion when going through all these marketing levels.

A second issue is the consumer dairy products index is composed of different dairy products such as cheese, butter and fluid milk. As is discussed in detail in "Asymmetry in Farm-Retail Price Transmission for Major Dairy Products" [15] the major dairy products - butter, cheese, fluid milk and ice cream - have asymmetric farm-retail marketing margins. Thus, producer and retail prices will have different relationships across regions because the product mix varies across regions.

A third confounding reason is that price uncertainty is different across

China. Research results conducted by Borrsen, Chavas, Grant and Schnake [6] showed increased price variability increased marketing margins. UHT milk in Hunan province would have more price volatility than fresh milk in Inner Mongolia.

A last major issue is that our research is conducted under an assumption of unilateral trade liberalization. We did not consider regional Asian or world trade liberalization effects on China. This issue, like the general equilibrium modeling approach, suggests a significant modeling challenge that at this point would strain beyond all reason the capacity of available date. However, it is the next logical extension to better understanding the global trade environment. Even in a global trade model, we would continue to argue that a geographically large and diverse country, like China, should be represented as regions.

APPENDIX A

CONSUMPTION RESULTS

Table A.1: Region 1: Nonlinear FIML Summary of Residual Errors

Equation	**DF Model**	**DF Error**	**SSE**	**MSE**	**Root MSE**	**R-Square**	**Adj R-Sq**	**Durbin Watson**
W_d	4.5	34.5	0.000043	1.235E-6	0.00111	0.8983	0.8880	1.9631
W_{ndf}	4.5	34.5	0.0151	0.000439	0.0209	0.9002	0.8900	1.8070

Table A.2: Region 1: Nonlinear FIML Parameter Estimates

Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > $\|t\|$**	**Label**
$\gamma 12$	-0.00014	0.00409	-0.03	0.9731	
$\gamma 21$	-0.00014	0.00409	-0.03	0.9731	
$\alpha 1$	-0.01544	0.00501	-3.08	0.0041	
$\beta 1$	0.010655	0.00181	5.88	<.0001	
$\gamma 11$	0.003476	0.00449	0.77	0.4440	
W_d_l1	0.933043	0.0627	14.88	<.0001	AR(Wd) Wd lag1 parameter
$\alpha 2$	1.062505	0.0798	13.31	<.0001	
$\beta 2$	-0.22907	0.0287	-7.98	<.0001	
$\gamma 22$	-0.03957	0.0334	-1.19	0.2440	
W_{ndf}_l1	0.844046	0.0945	8.93	<.0001	AR(Wndf) Wndf lag1 parameter
$Restrict0$	-19.7239	11.6623	-1.69	0.0910	$\gamma 12 - \gamma 21 = 0$

Table A.3: Region 2: Nonlinear FIML Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	AdjR-Sq	Durbin Watson
W_d	5.5	124.5	0.000436	0.0000035	0.00187	0.8772	0.8727	2.0387
W_{ndf}	4.5	125.5	0.1380	0.00110	0.0332	0.7975	0.7919	2.1557

Table A.4: Region 2: Nonlinear FIML Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > $\|t\|$	Label
$\gamma 12$	-0.00504	0.00297	-1.70	0.0923	
$\gamma 21$	-0.00504	0.00297	-1.70	0.0923	
$\alpha 1$	-0.00473	0.00373	-1.27	0.2071	
$\beta 1$	0.005174	0.00118	4.40	<.0001	
$\gamma 11$	0.005127	0.00371	1.38	0.1696	
W_d_l1	1.077215	0.0888	12.14	<.0001	AR(Wd) Wd lag1 parameter
W_d_l2	-0.18378	0.0890	-2.06	0.0410	AR(Wd) Wd lag2 parameter
$\alpha 2$	0.898465	0.0576	15.58	<.0001	
$\beta 2$	-0.13431	0.0178	-7.53	<.0001	
$\gamma 22$	0.131884	0.0276	4.78	<.0001	
W_{ndf}_l1	0.795733	0.0541	14.70	<.0001	AR(Wndf) Wndf lag1 parameter
$Restrict0$	-27.3434	15.8230	-1.73	0.0840	$\gamma 12 - \gamma 21 = 0$

Table A.5: Region 3: Nonlinear FIML Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	AdjR-Sq	Durbin Watson
W_d	5.5	163.5	0.000622	0.000003803	0.00195	0.8137	0.8085	2.0771
W_{ndf}	4.5	164.5	0.1130	0.000687	0.0262	0.8754	0.8728	2.0075

Table A.6: Region 3: Nonlinear FIML Parameter Estimates

Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > $\|t\|$**	**Label**
$\gamma 12$	-0.005	0.00256	-1.96	0.0522	
$\gamma 21$	-0.005	0.00256	-1.96	0.0522	
$\alpha 1$	-0.01659	0.00386	-4.29	<.0001	
$\beta 1$	0.008514	0.00132	6.47	<.0001	
$\gamma 11$	0.000593	0.00263	0.23	0.8218	
W_d_l1	1.034424	0.0750	13.79	<.0001	AR(Wd) Wd lag1 parameter
W_d_l2	-0.16593	0.0759	-2.19	0.0303	AR(Wd) Wd lag2 parameter
$\alpha 2$	1.024342	0.0492	20.84	<.0001	
$\beta 2$	-0.18412	0.0169	-10.92	<.0001	
$\gamma 22$	0.016413	0.0204	0.81	0.4211	
W_{ndf}_l1	0.862744	0.0350	24.62	<.0001	AR(Wndf) Wndf lag1 parameter
$Restrict0$	-99.159	28.2960	-3.50	0.0004	$\gamma 12 - \gamma 21 = 0$

Table A.7: Region 4: Nonlinear FIML Summary of Residual Errors

Equation	**DF Model**	**DF Error**	**SSE**	**MSE**	**Root MSE**	**R-Square**	**AdjR-Sq**	**Durbin Watson**
W_d	4.5	34.5	0.000078	0.000002274	0.00151	0.6183	0.5796	1.5187
W_{ndf}	4.5	34.5	0.0124	0.000358	0.0189	0.9326	0.9258	1.9927

Table A.8: Region 4: Nonlinear FIML Parameter Estimates

Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
$\gamma12$	0.002981	0.00406	0.73	0.4680	
$\gamma21$	0.002981	0.00406	0.73	0.4680	
$\alpha1$	-0.00721	0.00576	-1.25	0.2192	
$\beta1$	0.007347	0.00200	3.66	0.0008	
$\gamma11$	-0.00127	0.00379	-0.34	0.7390	
W_d_l1	0.560667	0.1522	3.68	0.0008	AR(Wd) Wd lag1 parameter
$\alpha2$	1.166793	0.0842	13.85	<.0001	
$\beta2$	-0.24735	0.0293	-8.44	<.0001	
$\gamma22$	-0.00247	0.0298	-0.08	0.9346	
W_{ndf}_l1	0.697915	0.1266	5.51	<.0001	AR(Wndf) Wndf lag1 parameter
$Restrict0$	-7.88709	16.7740	-0.47	0.6452	$\gamma12 - \gamma21 = 0$

APPENDIX B

PRODUCTION RESULTS

Table B.1: Region 1 OLS Results for Equation (4.5)

Number of obs = 33				
F(6, 26) = 34.14	Source	SS	df	MS
Prob>F = 0.0000	Model	14.1077147	6	2.35128579
R-squared = 0.8874	Residual	1.79050776	26	.068865683
Adj R-squared = 0.8614	Total	15.8982225	32	0.496819452
Root MSE = .26242				

lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnY_{t-1}	.5827473	.1218243	4.78	0.000	.3323338	.8331608
lnP_{t-1}	2.08897	.9345116	2.24	0.034	.1680544	4.009887
lnF_{t-1}	-1.502368	.6694054	-2.24	0.034	-2.878351	-.126386
lnN_t	.2756133	.1533337	1.80	0.084	-.0395686	.5907951
$dummy_1$area==Hebei	dropped					
$dummy_2$area==Heilongjiang	.6001758	.1919891	3.13	0.004	.2055367	.994815
$dummy_3$area==InnerMongolia	.2617803	.1545187	1.69	0.102	-.0558374	.579398
constant	-2.214744	1.591602	-1.39	0.176	-5.486329	1.056842

Table B.2: Test for Heterodasticity and Autocorrelation

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	
Ho	Constant variance
Variables	fitted values of lnY
chi2(1)	0.17
Prob>chi2	0.6837
Durbin-Watson D	0.934

Table B.3: Region 1 GLS Results for Equation (4.5)

Coefficients	generalized least squares
Panels	homoskedastic
Correlation	common AR(1) coefficient for all panels (0.4162)
Estimated covariances	1
Estimated autocorrelations	1
Estimated coefficients	7
Number of obs	33
Number of groups	3
Time periods	11
Wald chi2(6)	157.79
Prob>chi2	0.0000

lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnY_{t-1}	.5410966	.1021621	5.30	0.000	.3408627	.7413306
lnP_{t-1}	1.421511	.7667625	1.85	0.064	-.0813162	2.924338
lnF_{t-1}	-.8029053	.5342321	-1.50	0.133	-1.849981	.2441704
lnN_t	.1427327	.1069913	1.33	0.182	-.0669663	.3524317
$dummy_1$area==Hebei	-.6076996	.1815044	-3.35	0.001	-.9634417	-.2519574
$dummy_2$area==Heilongjiang	dropped					
$dummy_3$area==InnerMogolia	-.406214	.1496188	-2.71	0.007	-.6994613	-.1129666
constant	-1.055149	1.451504	-0.73	0.467	-3.900045	1.789747

Table B.4: Region 1 OLS Results for Equation (4.7)

Number of obs = 36				
F(4, 31) = 4.68	Source	SS	df	MS
Prob>F = 0.0045	Model	2.1246228	4	.531155699
R-squared = 0.3763	Residual	3.5209843	31	.113580139
Adj R-squared = 0.2959	Total	5.64560709	35	.16130306
Root MSE = .33702				

lnN_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnP_t	1.022441	.4759445	2.15	0.040	.0517463	1.993137
year	.0048816	.0296996	0.16	0.871	-.0556911	.0654543
$dummy_1$area==Hebei	dropped					
$dummy_2$area==Heilongjiang	.1824139	.1385657	1.32	0.198	-.1001926	.4650205
$dummy_3$area==InnerMongolia	.1450337	.1382287	1.05	0.302	-.1368856	.4269531
constant	-10.75759	57.32628	-0.19	0.852	-127.6753	106.1601

Table B.5: Test for Heterodasticity and Autocorrelation

Breusch-Pagan/Cook-Weisberg test for heteroskedasticity	
Ho	Constant variance
Variables	fitted values of *lnN*
chi2(1)	0.28
Prob>chi2	0.5967
Durbin-Watson D	1.781

Table B.6: Region 2 OLS Results for Equation (4.5)

Number of obs = 110				
F(13, 96) = 266.73	Source	SS	df	MS
Prob>F = 0.0000	Model	43.6209119	13	.531155699
R-squared = 0.9731	Residual	1.20769348	96	.113580139
Adj R-squared = 0.9694	Total	44.8286054	109	.16130306
Root MSE = .11216				

lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnY_{t-1}	.8404384	.0603619	13.92	0.000	.720621	.9602558
lnP_{t-1}	.2398118	.1358994	1.76	0.081	-.0299463	.5095699
lnF_{t-1}	-.0576352	.1389142	-0.41	0.679	-.3333777	.2181074
lnN_t	.1986788	.0435818	4.56	0.000	.1121696	.2851879
$dummy_1$area==Beijing	.0472731	.0716018	0.66	0.511	-.0948554	.1894015
$dummy_2$area==Fujian	.0865175	.0509715	1.70	0.093	-.0146602	.1876951
$dummy_3$area==Guangdong	dropped					
$dummy_4$area==Jiangsu	.084836	.0592554	1.43	0.155	-.0327851	.202457
$dummy_5$area==Jilin	-.088211	.0530344	-1.66	0.100	-.1934835	.0170614
$dummy_6$ area==Liaoning	.000931	.062903	0.01	0.988	-.1239305	.1257925
$dummy_7$area==Shandong	.0947946	.0688465	1.38	0.172	-.0418647	.2314539
$dummy_8$area==Shanghai	-.0194082	.0773211	-0.25	0.802	-.1728895	.134073
$dummy_9$area==Tianjin	.1062374	.0617961	1.72	0.089	-.0164269	.2289018
$dummy_1$0area==Zhejiang	.0146745	.0578446	0.25	0.800	-.100146	.1294951
constant	-.794546	.2451002	-3.24	0.002	-1.281066	-.3080261

Table B.7: Test for Heterodasticity and Autocorrelation

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	
Ho	Constant variance
Variables	fitted values of lnY
chi2(1)	7.21
Prob>chi2	0.0073
Durbin-Watson D	1.809

Table B.8: Region 2 GLS Results for Equation (4.5)

Coefficients	generalized least squares
Panels	homoskedastic
Correlation	common AR(1) coefficient for all panels (0.4162)
Estimated covariances	10
Estimated autocorrelations	0
Estimated coefficients	14
Number of obs	110
Number of groups	10
Time periods	11
Wald chi2(6)	6702.73
Prob>chi2	0.0000

lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnY_{t-1}	.7981483	.0493634	16.17	0.000	.7013978	.8948988
lnP_{t-1}	.2428578	.0862239	2.82	0.005	.0738621	.4118535
lnF_{t-1}	-.1161171	.0965117	-1.20	0.229	-.3052766	.0730425
lnN_t	.2611884	.0372616	7.01	0.000	.188157	.3342198
$dummy_1$area==Beijing	.0593981	.0782142	0.76	0.448	-.093899	.2126952
$dummy_2$area==Fujian	.0990307	.0669623	1.48	0.139	-.032213	.2302745
$dummy_3$area==Guangdong	dropped					
$dummy_4$area==Jiangsu	.1014033	.0755121	1.34	0.179	-.0465977	.2494042
$dummy_5$area==Jilin	-.1195879	.0721433	-1.66	0.097	-.2609861	.0218103
$dummy_6$area==Liaoning	.0032165	.0757586	0.04	0.966	-.1452675	.1517006
$dummy_7$area==Shandong	.0765677	.0756735	1.01	0.312	-.0717496	.2248849
$dummy_8$area==Shanghai	.009778	.0802705	0.12	0.903	-.1475494	.1671053
$dummy_9$area==Tianjin	.1310399	.0737281	1.78	0.076	-.0134645	.2755444
$dummy_1$0area==Zhejiang	.0353803	.0752391	0.47	0.638	-.1120855	.1828462
constant	-.5156299	.1861232	-2.77	0.006	-.8804247	-.150835

Table B.9: Region 2 OLS Results for Equation (4.7)

Number of obs = 120				
F(15,108) = 37.07	Source	SS	df	MS
Prob>F = 0.0000	Model	42.9593655	11	3.90539687
R-squared = 0.7906	Residual	11.3781301	138	
Adj R-squared = 0.7693	Total	54.3374956	119	0.45661761
Root MSE = .32458				

lnN_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnP_t	-1.004174	.1979866	-5.07	0.000	-1.396618	-.6117304
year	.161712	.0141256	11.45	0.000	.1337125	.1897114
$dummy_1$ area==Beijing	1.127681	.1348956	8.36	0.000	.8602946	1.395067
$dummy_2$ area==Fujian	dropped					
$dummy_3$ area==Guangdong	.1490934	.1331247	1.12	0.265	-.1147828	.4129695
$dummy_4$ area==Jiangsu	.7443496	.1362833	5.46	0.000	.4742124	1.014487
$dummy_5$ area==Jilin	1.068314	.1326012	8.06	0.000	.805475	1.331152
$dummy_6$ area==Liaoning	1.102601	.132748	8.31	0.000	.8394711	1.36573
$dummy_7$ area==Shandong	1.547089	.1326709	11.66	0.000	1.284112	1.810066
$dummy_8$ area==Shanghai	.961108	.1415761	6.79	0.000	.6804795	1.241736
$dummy_9$ area==Tianjin	.5112597	.1375972	3.72	0.000	.2385182	.7840011
$dummy_1 0$ area==Zhejiang	.4862425	.1380719	3.52	0.001	.21256	.759925
constant	-316.8919	27.42893	-11.55	0.000	-371.2608	-262.523

Table B.10: Test for Heterodasticity and Autocorrelation

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	
Ho	Constant variance
Variables	fitted values of lnN_t
chi2(1)	13.43
Prob>chi2	0.0002
Durbin-Watson D	0.881

Table B.11: Region 2 GLS Results for Equation (4.7)

Coefficients	generalized least squares
Panels	homoskedastic
Correlation	common AR(1) coefficient for all panels (0.4162)
Estimated covariances	10
Estimated autocorrelations	1
Estimated coefficients	12
Number of obs	120
Number of groups	10
Time periods	12
Wald chi2(6)	355.12
Prob>chi2	0.0000

lnN_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnP_t	-1.178742	.153494	-7.68	0.000	-1.479585	-.8778992
year	.1721633	.0122891	14.01	0.000	.1480771	.1962495
$dummy_1$area==Beijing	.6180516	.1194321	5.17	0.000	.383969	.8521342
$dummy_2$area==Fujian	-.5223236	.1364977	-3.83	0.000	-.7898541	-.2547931
$dummy_3$area==Guangdong	-.3714442	.1827127	-2.03	0.042	-.7295545	-.0133339
$dummy_4$area==Jiangsu	.2650111	.175167	1.51	0.130	-.07831	.6083322
$dummy_5$area==Jilin	.4662528	.4167939	1.12	0.263	-.3506482	1.283154
$dummy_6$area==Liaoning	.563285	.1680814	3.35	0.001	.2338515	.8927186
$dummy_7$area==Shandong	.9816624	.2081721	4.72	0.000	.5736525	1.389672
$dummy_8$area==Shanghai	.3966343	.1719742	2.31	0.021	.0595711	.7336975
$dummy_9$ area==Tianjin	.0130575	.1393501	0.09	0.925	-.2600637	.2861787
$dummy_1$0	dropped					
constant	-336.3379	23.94766	-14.04	0.000	-383.2744	-289.4013

Table B.12: Region 3 OLS Results for Equation (4.6)

Number of obs = 154					
F(15,138) = 122.28	Source	SS	df	MS
Prob>F = 0.0000	Model	385.124366	15	25.6749
R-squared = 0.9300	Residual	28.9768056	138	0.20997
Adj R-squared = 0.9224	Total	414.101172	153	2.70654
Root MSE = .45823				

lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnP_t	1.407143	.4086999	3.44	0.001	.5990197	
lnF_t	-.4855603	.3858478	-1.26	0.210	-1.248498	.2773779
lnN_t	.1100666	.0378656	2.91	0.004	.0351949	.1849384
$dummy_1$	2.911309	.278646	10.45	0.000	2.360341	3.462276
$dummy_2$	1.938313	.2784251	6.96	0.000	1.387782	2.488844
$dummy_3$	2.214772	.2783107	7.96	0.000	1.664467	2.765077
$dummy_5$	4.035572	.3172375	12.72	0.000	3.408297	4.662846
$dummy_6$	3.286223	.3292959	9.98	0.000	2.635105	3.937341
$dummy_7$	1.984042	.2945853	6.74	0.000	1.401557	2.566527
$dummy_8$	3.250425	.2987152	10.88	0.000	2.659774	3.841075
$dummy_9$	4.240757	.3279923	12.93	0.000	3.592217	4.889297
$dummy_1 0$	4.943204	.3464509	14.27	0.000	4.258166	5.628243
$dummy_1 1$	4.909478	.3412884	14.39	0.000	4.234647	5.584309
$dummy_1 2$	4.836179	.3184965	15.18	0.000	4.206415	5.465943
$dummy_1 3$	3.761951	.3435544	10.95	0.000	3.08264	4.441262
constant	-6.398351	.8661554	-7.39	0.000	-8.111003	-4.685699

Table B.13: Test for Heterodasticity and Autocorrelation

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	
Ho	Constant variance
Variables	fitted values of lnY
chi2(1)	26.56
Prob>chi2	0.0000
Durbin-Watson D	1.815

Table B.14: Region 3 GLS Results for Equation (4.6)

Coefficients	generalized least squares
Panels	homoskedastic
Correlation	common AR(1) coefficient for all panels (0.4162)
Estimated covariances	13
Estimated autocorrelations	0
Estimated coefficients	16
Number of obs	154
Number of groups	13
Obs per group	min = 10
	avg = 11.84615
	max = 12
Wald chi2(6)	2520.56
Prob>chi2	0.0000

lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnP_t	1.420753	.2275651	6.24	0.000	.974734	1.866773
lnF_t	-.61273	.2285441	-2.68	0.007	-1.060668	-.1647917
lnN_t	.1495425	.0341794	4.38	0.000	.0825521	.216533
$dummy_1$area==Anhui	-1.948018	.1714542	-11.36	0.000	-2.284062	-1.611973
$dummy_2$area==Guangxi	-2.922247	.1907168	-15.32	0.000	-3.296045	-2.548449
$dummy_3$area==Guizhou	-2.654294	.1688208	-15.72	0.000	-2.985177	-2.323412
$dummy_4$area==Hainan	-4.676295	.3756166	-12.45	0.000	-5.41249	-3.9401
$dummy_5$area==Henan	-.8707339	.2337778	-3.72	0.000	-1.32893	-.4125379
$dummy_6$area==Hubei	-1.647793	.15868	-10.38	0.000	-1.9588	-1.336786
$dummy_7$area==Hunan	-2.896364	.2193585	-13.20	0.000	-3.326299	-2.466429
$dummy_8$area==Jiangxi	-1.636903	.1558432	-10.50	0.000	-1.94235	-1.331456
$dummy_9$area==Ningxia	-.6849322	.1343137	-5.10	0.000	-.9481823	-.4216821
$dummy_1$0area==Shaanxi	dropped					
$dummy_1$1area==Shanxi	-.0425307	.1170471	-0.36	0.716	-.2719388	.1868775
$dummy_1$2area==Sichuan	-.073557	.1439549	-0.51	0.609	-.3557035	.2085895
$dummy_1$3area==Yunnan	-1.180163	.1361039	-8.67	0.000	-1.446921	-.9134037
constant	-.9589224	.5007276	-1.92	0.055	-1.94033	.0224857

Table B.15: Region 3 OLS Results for Equation (4.7)

Number of obs = 156
F(15,138) = 37.92
Prob>F = 0.0000
R-squared = 0.7902
Adj R-squared = 0.7693
Root MSE = 1.03

Source	SS	df	MS
Model	563.309092	14	40.2363637
Residual	149.59973	141.1	
Total	712.908822	155.4	

lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnP_t	-.6740024	.5806576	-1.16	0.248	-1.821923	.4739179
year	.0917125	.0375359	2.44	0.016	.0175067	.1659184
$dummy_1$ area==Anhui	-2.247418	.4228517	-5.31	0.000	-3.083367	-1.411469
$dummy_2$ area==Guangxi	-2.580763	.4239079	-6.09	0.000	-3.4188	-1.742726
$dummy_3$ area==Guizhou	-2.193008	.4382758	-5.00	0.000	-3.059449	-1.326567
$dummy_4$ area==Hainan	-7.479215	.4683982	-15.97	0.000	-8.405206	-6.553223
$dummy_5$ area==Henan	-.977291	.4494661	-2.17	0.031	-1.865855	-.0887273
$dummy_6$ area==Hubei	-.3885239	.4343004	-0.89	0.373	-1.247106	.4700582
$dummy_7$ area==Hunan	-1.686815	.4451884	-3.79	0.000	-2.566922	-.8067085
$dummy_8$ area==Jiangxi	-1.491801	.4405847	-3.39	0.001	-2.362807	-.6207951
$dummy_9$ area==Ningxia	-.4880943	.4211993	-1.16	0.248	-1.320776	.3445878
$dummy_1$0 area==Shaanxi	.0611255	.4413032	0.14	0.890	-.8113008	.9335517
$dummy_1$1area==Shanxi	-.0002394	.4333055	-0.00	1.000	-.8568548	.8563759
$dummy_1$2 area==Sichuan	-.7424696	.4210443	-1.76	0.080	-1.574845	.0899061
$dummy_1$3 area==Yunnan	dropped					
constant	-177.4469	72.66009	-2.44	0.016	-321.0909	-33.80286

Table B.16: Test for Heterodasticity and Autocorrelation

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	
Ho	Constant variance
Variables	fitted values of lnN_t
chi2(1)	172.99
Prob>chi2	0.0000
Durbin-Watson D	1.339

Table B.17: Region 3 GLS Results for Equation (4.7)

Note: dummy13 dropped because of collinearity	
Cross-sectional time-series FGLS regression	
Coefficients	generalized least squares
Panels	homoskedastic
Correlation	common AR(1) coefficient for all panels
Estimated covariances	13
Estimated autocorrelations	1
Estimated coefficients	15
Number of obs	156
Number of groups	13
Obs per group	min = 12
Wald chi2(6)	921.34
Prob>chi2	0.0000

lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnP_t	-.2106084	.1940278	-1.09	0.278	-.5908959	.1696792
year	.080834	.0133963	6.03	0.000	.0545777	.1070903
$dummy_1$ area==Anhui	-2.072779	1.247748	-1.66	0.097	-4.51832	.3727625
$dummy_2$ area==Guangxi	-2.543273	.1477379	-17.21	0.000	-2.832834	-2.253712
$dummy_3$ area==Guizhou	-2.021332	.2597685	-7.78	0.000	-2.530469	-1.512195
$dummy_4$ area==Hainan	-7.264085	1.137529	-6.39	0.000	-9.493601	-5.03457
$dummy_5$ area==Henan	-.863249	.2861394	-3.02	0.003	-1.424072	-.3024261
$dummy_6$ area==Hubei	-.3300821	.3255443	-1.01	0.311	-.9681372	.3079729
$dummy_7$ area==Hunan	-1.607834	.4336187	-3.71	0.000	-2.457711	-.7579569
$dummy_8$ area==Jiangxi	-1.382988	.1523716	-9.08	0.000	-1.681631	-1.084346
$dummy_9$ area==Ningxia	-.4881167	.2274929	-2.15	0.032	-.9339947	-.0422387
$dummy_1 0$ area==Shaanxi	.1842553	.1918906	0.96	0.337	-.1918435	.560354
$dummy_1 1$area==Shanxi	.0487613	.1698249	0.29	0.774	-.2840893	.3816119
$dummy_1 2$ area==Sichuan	-.7177139	.1758013	-4.08	0.000	-1.062278	-.3731497
$dummy_1 3$	dropped					
constant	-158.138	25.99185	-6.08	0.000	-209.0811	-107.1949

Table B.18: Region 4 OLS Results for Equation (4.6)

Number of obs = 36				
F(5,30) = 167.10	Source	SS	df	MS
Prob>F = 0.0000	Model	16.8366556	5	3.36733112
R-squared = 0.9653	Residual	.604532797	30	.020151093
Adj R-squared = 0.9653	Total	17.4411884	35	.498319668
Root MSE = .14195				

lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnP_t	.5499467	.3860897	1.42	0.165	-.2385538	1.338447
lnF_t	-.5195424	.2673521	-1.94	0.061	-1.065548	.0264635
lnN_t	.8432921	.1324704	6.37	0.000	.5727515	1.113833
$dummy_1$ area==Gansu	-1.059971	.127346	-8.32	0.000	-1.320047	-.7998962
$dummy_2$ area==Qinghai			dropped			
$dummy_3$ area==Xinjiang	-.9225076	.3027447	-3.05	0.005	-1.540795	-.3042205
constant	1.060209	.8006343	1.32	0.195	-.5749041	2.695323

Table B.19: Test for Heterodasticity and Autocorrelation

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	
Ho	Constant variance
Variables	fitted values of lnY
chi2(1)	0.49
Prob>chi2	0.485
Durbin-Watson D	2.205

Table B.20: Region 4 OLS Results for Equation (4.7)

Number of obs = 36				
F(4,31) = 945.47	Source	SS	df	MS
Prob>F = 0.0000	Model	35.5126921	4	8.87817302
R-squared = 0.9919	Residual	.29109583	31	.009390188
Adj R-squared = 0.9908	Total	35.8037879	35	1.02296537
Root MSE = .0969				

lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnP_t	.1962858	.1127597	1.74	0.092	-.0336891	.4262607
year	.0796867	.0076515	10.41	0.000	.0640813	.0952921
$dummy_1$ area==Gansu	dropped					
$dummy_2$ area==Qinghai	-.8264791	.0405653	-20.37	0.000	-.9092127	-.7437456
$dummy_3$ area==Xinjiang	1.409109	.0516692	27.27	0.000	1.303728	1.514489
constant	-157.0847	14.84325	-10.58	0.000	-187.3577	-126.8117

Table B.21: Test for Heterodasticity and Autocorrelation

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	
Ho	Constant variance
Variables	fitted values of lnY
chi2(1)	2.98
Prob>chi2	0.0843
Durbin-Watson D	0.605

Table B.22: Region 4 GLS Results for Equation (4.7)

Note: dummy3 dropped because of collinearity						
Cross-sectional time-series FGLS regression						
Coefficients	generalized least squares					
Panels	homoskedastic					
Correlation	common AR(1) coefficient for all panels					
Estimated covariances	3					
Estimated autocorrelations	1					
Estimated coefficients	5					
Number of obs	36					
Number of groups	3					
Obs per group	min = 12					
Wald chi2(6)	2357.92					
Prob>chi2	0.0000					
lnY_t	Coef.	Std. Err.	t	$P > \|t\|$	[95% Conf.	Interval]
lnP_t	-.0201641	.0957996	-0.21	0.833	-.2079278	.1675997
year	.096172	.0080323	11.97	0.000	.0804291	.111915
$dummy_1$ area==Gansu	-1.516873	.0834215	-18.18	0.000	-1.680376	-1.353369
$dummy_2$ area==Qinghai	-2.286242	.0551318	-41.47	0.000	-2.394298	-2.178185
constant	-187.4513	15.66376	-11.97	0.000	-218.1517	-156.7509

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