Total Elasticities for Meat in China:
The Importance of Cross-commodity Effects

by

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Abstract

Several major trends have been driving the increase of meat consumption in China. By using equilibrium displacement modeling, we focused on the factors of rapid income growth and a pork price subsidy. In a single commodity market, theory predicts that the total income elasticities are less than the partial responses of quantities to income growth. However, when the model was specified to China's five products meat market, counter-intuitive simulation results were obtained, which led us to an important finding of this study: results in the multi-commodity market do not conform to those in the single commodity market, due to the influence of cross-commodity effects. Our analysis shows that substitution or complementary effects may cause the "quasi-singularity" problem of the comparative static results matrices, during matrix inversion. The values of cross-commodity elasticities could influence the results significantly, that is, the relative changes of endogenous variables (prices and quantities) with respect to exogenous variables (e. g. income) could be represented as a function of the cross-commodity elasticities, in the form of, or approximately relating to a hyperbola curve. Unlike the income effects, results indicate that a pork price subsidy would influence other meat very slightly. Results also suggest that a pork subsidy would benefit both meat producers and consumers in the market, and the less elastic side enjoys more welfare, as expected.

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List of Abbreviations

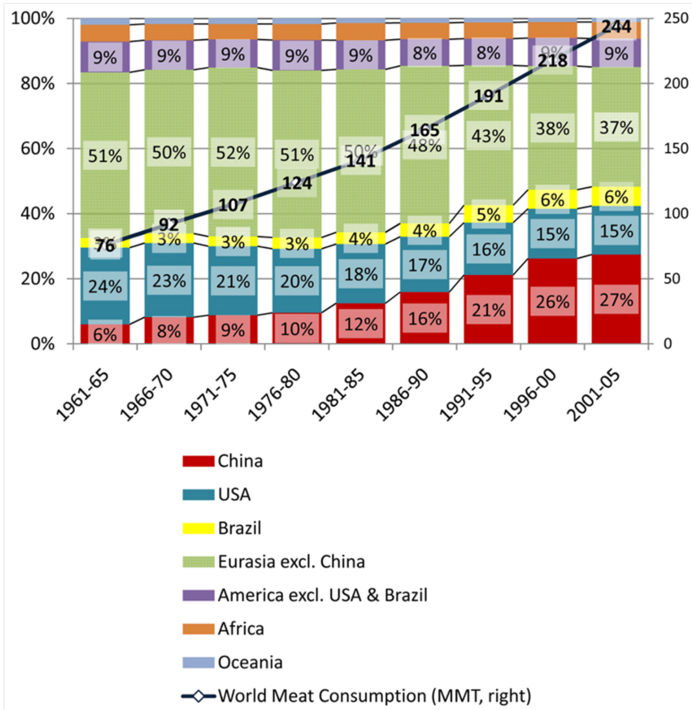
AIDS	Almost Ideal Demand System
CRTS	Constant Return To Scales
EDM	Equilibrium Displacement Model
ERS	Economic Research Service
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
MMT	Million Metric Tons
NBS	National Bureau of Statistics, China
NDRC	National Development and Reform Commission, China
USDA	United States Department of Agriculture
WDI	World Development Indicators
WTO	World Trade Organization

Chapter 1

Introduction

Livestock products, which are important and an appealing nutrient sources for human beings, make up over half of the agricultural output in developed countries, compared with only a third of the total in developing countries. The share in developing countries is rising rapidly principally due to rapidly growing demand for livestock products (Bruinsma 2003). While in developed countries, where people have already enjoyed adequate supplies of animal protein and micronutrients, livestock production has had a only 1.0% growth rate in the past 30 years. Many people in developing countries still subsist on diets that are almost entirely made up of starchy staples. 23% of the world's population living in developed countries consume three to four times the meat per capita and fish and five to six times the milk as those in developing countries (Delgado et al. 1999). But massive annual increases in the consumption of livestock products are occurring in developing countries. The trends in East Asia, mainly in China, are highest, with livestock product growth rates of over 7% per year in the past 30 years, albeit from a low base (Ehui et al. 2002). Population growth, urbanization, and income growth in developing countries are fueling a massive global increase in demand for food of animal origin, which has been called "Livestock Revolution" (Delgado et al. 1999).

With less than 7% of the world's arable land and almost 25% of the world's population, China has been essentially self-sufficient in agricultural production, and has been focused on establishing food security and rural social stability. China is the world's largest agricultural producer in terms of volume (while the United States is the largest in terms of value) and it is the world's largest producer and consumer of livestock products as well. Livestock is a key sector in China's agriculture, and a top priority target for rapid development and



Source: Masuda and Goldsmith, 2009

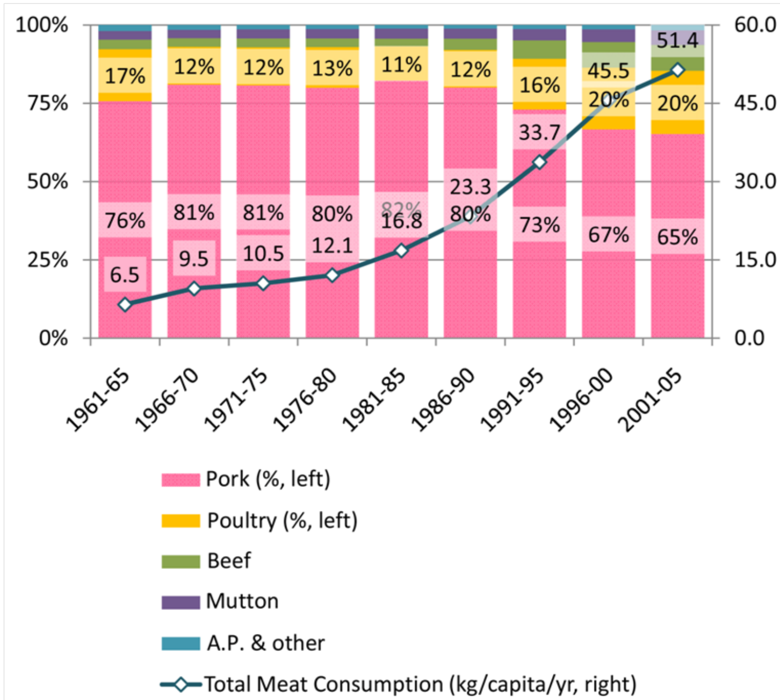
Figure 1.1: Meat Consumption Quantity Share of China, USA, Brazil and Continents

modernization. China has more than 400 million cattle, sheep and goats, but pork and poultry products are the most popular meat consumed in China. However, the consumption of beef and beef products, fresh milk, and dairy products such as yogurt, is increasing rapidly and is strongly encouraged by the Chinese government as an approach of improving national health.

Poor food product quality, safety and unreliability are major problems for the Chinese consumers and have been plaguing China's market access efforts.

1.1 Forces and Drivers of Change of Meat Consumption

Several major trends affect consumption of meat products, including rising income, population growth and changing demographics, changing markets and technologies for food, new scientific knowledge about diet and health, consumer preferences and information about the foods they eat. Increasing globalization through trade liberalization, as well as new



Source: Masuda and Goldsmith, 2009

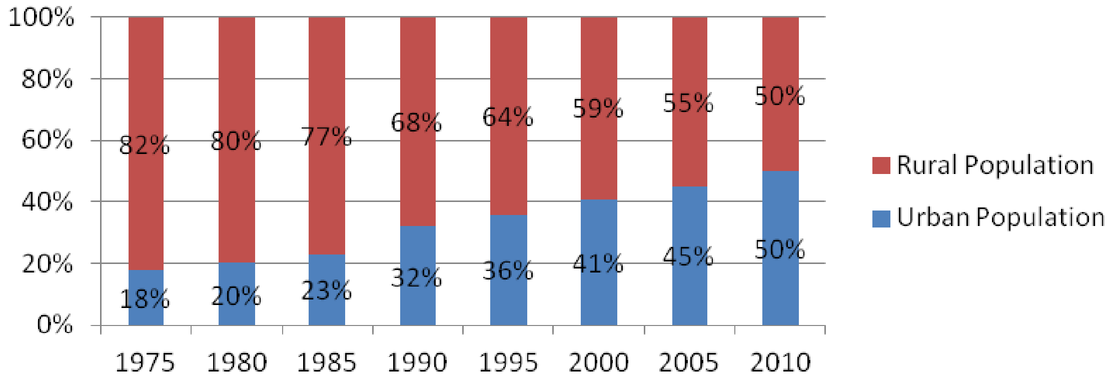
Figure 1.2: China's Meat Consumption and Its Composition (1961-2005)

information and transportation technologies, has changed the perspective of the consumer of products.

1.1.1 Population Growth and Changing Demographics

Population growth and other demographic factors affect food consumption in several ways. Location and population density generate different employment and market opportunities; dietary needs change throughout the life cycle; and ethnic and cultural differences affect preferences for foods. Growth of population in China and the rest of the world will lead to increased demand for food. The growth rate of China's population, however, according to the sixth national population census by the Chinese government on November 1, 2010, is only 0.47%, ranking 156th in the world.

Increased urbanization of China's population leads to more food establishments, and more meals and snacks eaten away from home. About half of the population lived in rural areas in 2010, while 80% lived in rural areas 20 years ago. In cities, women have entered the

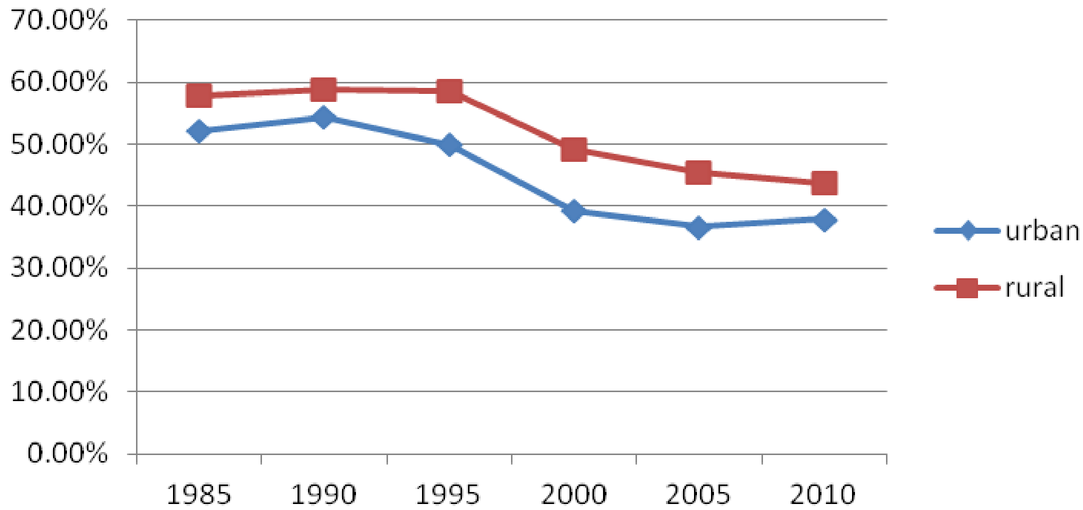


Source: USDA data

Figure 1.3: Ratio of Rural and Urban Population

formal labor markets more than in rural areas. The employment of more women in the paid labor sector has reduced the available time women have to prepare meals at home; hence this change has led to an increase in the purchase, preparation and consumption of convenient foods. Such foods are purchased at convenient locations and times, prepared with little time input and often eaten outside the home. All these have resulted in significant social and economic change. The related trend toward more dual-career families, where both partners live in an urban area or where one rural partner commutes to work in an urban area, is likely to continue to boost away from-home and prepared food expenditures. Urban households consume more prepared foods and, due to geographic proximity, are more likely to have prepared foods delivered to the home. Urban dwellers consume more processed than fresh foods and less pork and beef compared to rural residents (USDA–ERS, 2005).

In China, especially in cities, average household size is becoming smaller, there are fewer and fewer traditional Chinese families where three or more generations are living together. There are more young adults living on their own, more single parents with children, and more single-person households. People in smaller households eat more food away from home, spend more per capita on food, and when eating at home, prefer more processed and ready-to-eat foods.



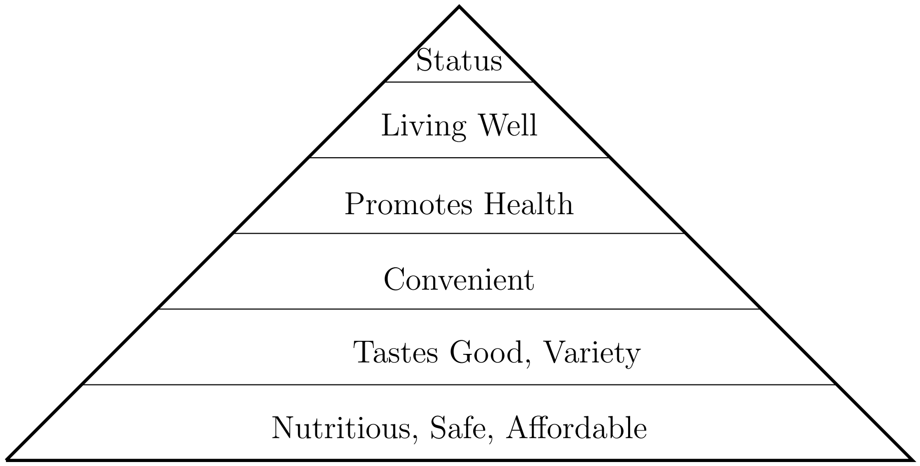
Source: China Statistics Almanac, China Finance Almanac, and author's calculation

Figure 1.4: Urban and Rural Expenditure Proportions on Food

Another major demographic trend affecting meat markets is that the population of China is becoming older as people are living longer and birth rates are relatively low. Older consumers eat less total food and are likely to have different food preferences. Obesity affects all ages. However, changes in metabolism lessen the ability of older people to engage in strenuous exercise, and increase their susceptibility to weight gain. Demand by the older generation for the health attributes of meat are expected to influence demand for meat (Lin et al., 2003). With increased attention to choosing a diet that may reduce heart and stroke disease risks, older consumers can also be expected to consume more fruits, vegetables and fish (Blisard et al., 2002).

1.1.2 Income

Household income is also an important determinant of the amount and types of foods purchased. As income rises, people purchase more food, though the percentage of income spent on food declines. As income rises, consumers shift from grains to animal protein sources; and with further increases consumers' preferences for animal protein. Income provides consumers with the ability to purchase food and other goods and is an important



Source: Kinsey, 2000

Figure 1.5: Consumer Food Demand Pyramid

determinant of the level and types of goods and services purchased. During the last 25 years, income has increased significantly worldwide. The World Bank predicts that during the period 2000 to 2015, per-capita income growth in most areas of the world will continue to grow, with the exception of East Asia (Bruinsma, 2003). Higher income allows consumers to spend more on food and have greater discretion on spending for preferred foods from animal protein sources and specialized food products. The consumer food demand pyramid, illustrated in figure 1.5, presents a simple model of the consumer choice process (Kinsey, 2000).

The idea of a food demand pyramid suggests that low-income consumers focus first on meeting survival needs (the base of the pyramid): obtaining sufficient calories, lower priced foods and safe foods are basic concerns. At lower income levels, food safety may imply foods that are not spoiled. At higher income levels, consumers begin to use their money to purchase products that satisfy preferences above and beyond basic nutritional needs, such as better taste, variety and convenience. Once needs lower on the food pyramid have been met, consumers at higher income levels want expanded information about their food, and how food products affect health and lifestyle. High-income consumers also begin to be concerned about the impact that individual food consumption decisions and choices have on other people, the environment and animals. Thus, as incomes increase, the demand for food products with different characteristics evolves, presenting both opportunities and threats to existing and potential food producers. Higher income consumers provide opportunities for niche producers that are willing and able to produce to this diverse set of standards. However, low-to-moderate-income families in developed countries and people in developing economies still demand an increasing amount of affordable animal proteins. (Farm Foundation, 2006)

As income levels increase, consumers buy more food and change the form and quality of food they purchase. They devote less time and effort to food preparation and reallocate spending away from raw food products to foods with various amounts of preparation or processing. Consumers also eat a larger share of their food away from home. The entry of more women into the labor force also contributes to demand for more services in the food products purchased. Recent consumer surveys indicate that consumers continue to look for ways to reduce the time for food and meat preparation. These changes will create opportunities for more value-added animal products. Value is added through innovative processing and preparation and in new and improved products and production characteristics. Consumers are also placing greater trust in others for the safety and quality of the product.

Rising incomes in the general population have fuelled the steady growth in the livestock sector, particularly in swine, poultry, aquaculture, and dairy product, which have also led to increased demand for basic animal feed and protein sources, driving up prices such as of corn and soybeans.

1.2 Agricultural Economy and Policy in China

China has changed significantly since its economic reforms beginning in 1978. The reforms included price liberalization, fiscal decentralization, increased autonomy for state enterprises, the development of a diversified banking system, and stock markets. And it has transitioned from a centrally-planned economy to a rapid growing market-oriented economy, as one of the most important players in global trade. China also experienced unprecedented

GDP growth of between 8% and 12% per year. Prior to 1978, the prices of 97% commodities and services were determined by the government. By 2007, the prices of 95.6% of retail, 97.1% of agricultural procurement, and 92.4% of production material sales were determined by the market (NDRC, 2008).

1.2.1 12th Five Year Plan for Meat Industry

According to China's 12th Five Year Plan to 2015, government and industry will promote the construction of large slaughterhouses and processing facilities in major animal producing areas in order to reduce inter-province animal transport and the spread of animal diseases. The central government has designated 19 provinces for the primary development of the country's livestock industry by the year 2015. Under this policy, the central government stresses the importance of industry transformation in three main areas: breeding, processing operations (manual to mechanized), and logistics (backyard to modern cold chain). To achieve the transformation, to phase in "backward" processing facilities, and to reduce illicit slaughter activities, the government has outlined certain detailed objectives as part of the 12th Five Year Plan. Objectives include decreasing the number of livestock slaughterhouses to 3,000 by 2015. Currently, China has 21,000 slaughter facilities, 90 percent of which are manual, small, or semi-mechanized. The government also asserts that by 2015, pork production should account for 61 percent (52.3 MMT) of total meat production. Over the next ten years, the government estimates swine production will grow by 20 MMT.

1.2.2 WTO

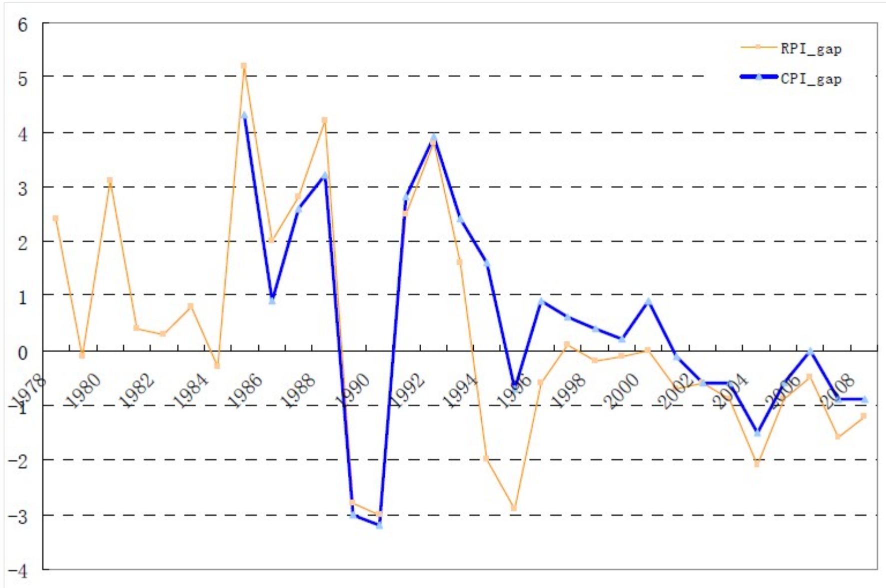
China joined the WTO (World Trade Organization) in December of 2001 with full membership obligations being phased in over ten years. In exchange for substantial tariff reductions and a wide range of market access concessions, covering nearly every sector of the economy, China gained greater access to WTO member countries, especially those countries that were less open than the United States. The accession agreement implementation is inconsistent, especially for agriculture, and certain areas remain contentious.

1.3 The Dual Demand Market

Despite the rapid growth in China's livestock, the disparity over regional development in China has increased. Urban incomes are more than twice of their rural counterparts, while average per capital rural incomes are still only $350 per year (NBS, 2010), and the western provinces have much higher rates of both rural and urban poverty than South China and the coastal provinces.

Transportation and trade costs represent a wedge between the seller's price and the buyer's price. The wedge lowers the seller's price, raises the buyer's price, and reduces the quantity traded. At the beginning of this century, transportation and storage costs were so high that they accounted for nearly 60 percent of total costs of food and livestock (Hertzell, 2001). With respect to meat transportation, only 10 percent of meat is transported using refrigerated trucks (Pei, 2009). Half of China's 12 million ton cold storage capacity is allocated to meat products, which is obviously too limited. The overall lack of cold chain infrastructure, with 25 to 30 percent of fresh produce lost during harvest, transit, and storage, has presented a barrier to marketing meat products from production areas.

Overcoming distance has always been an important issue in marketing agricultural products, but agricultural economists have examined the role of distance only occasionally (Coyle, 2001). Venables (2001) classifies the costs of distance into four types: the cost of moving goods (direct shipping costs); search costs (the cost of identifying potential trading partners); control and management costs; and the cost of time involved in shipping goods. Hummels and Skiba (2004) provided strong evidence against a widely used assumption in the trade literature: that transportation costs are of the "iceberg" form, proportional to prices of goods.



Source: Zhang X, 2010

Figure 1.6: Urban-rural Price Index Differences (1978-2008)

“The analysis of international trade makes virtually no use of insights from economic geography or location theory. We normally model countries as dimensionless points within which factors of production can be instantly and costlessly moved from one activity to another, and even trade among countries is usually given a sort of spaceless representation in which transport costs are zero for all goods that can be traded.” (Paul Krugman, 1996)

The Law of One Price specifies that under a perfect market economy, the prices of a commodity should be equal in different countries, given transportation costs, trade barrier and information costs. Accordingly, market segregation will lead to different prices in different regions, and if so, the profit-seeking behavior of market participants will bring the prices in different regions to the same level. Most of the previous studies have focused on the application of the Law of One Price in different countries (Engel & Rogers, 1996), while a few on the law in different cities of one country (Cecchetti, et. al., 2002). Even fewer studies have explored price differences between urban and rural areas partly due to data availability. The price difference between rural and urban areas in China calls for more attention, especially in light of the transformation of pricing mechanisms and the increasing urban-rural gaps in income and growth. For many years, the duality of Chinese economy has segregated the urban and rural markets, and caused urban–rural price differences. With the deepening of reform, the differences between urban and rural pricing level have also varied. Prior to 1978, the urban-rural price differences were limited as most prices were determined by the government. In the following 15 years, the inflation indexes in the urban areas had been higher than those of the rural areas, meaning that the urban price level increases at a faster pace. Starting in 1994, especially after China joined WTO in 2001, rural price indexes have been higher than those in the urban areas, indicating reduced urban-rural price differences. (Zhang X, 2010)

Chapter 2

Methodology

2.1 Equilibrium Displacement Model

The choice of a functional form is at the interface of both economic theory and the data. The method used in this study involves the use of a general and partial equilibrium framework, which is sometimes referred to as equilibrium displacement models (EDMs), also known as the "hat calculus models". Muth (1964) established a six equations system of reduced form which now known as "Muth modeling". By considering displacements and taking the total derivatives from the initial equilibrium, he found it convenient to express the equations in differential form, or, the relative changes and the elasticities. Moreover, he considered some applications of the analysis developed to problems from housing and urban land economics, which illustrated how useful the reduced form analysis could be in practical applications.

Piggott (1992) encouraged greater use of EDM. With EDM, there is more attention given to finite changes in exogenous variables and changes in both endogenous and exogenous variables are measured in proportionate terms or as ratios of proportionate changes (i.e. elasticities). He discussed the strength of EDMs in policy analysis. EDM involves the comparative statics analysis of general function models. It is such a powerful method that it allows qualitative assessments to be made of the impacts on endogenous variables of infinitely small changes in exogenous variables, and allows headway to be made in measuring the displacement effects of small finite changes in exogenous variables in situations where there is neither the time nor research resources available to engage in econometric modeling. It provides a first-order approximation to the effects of finite changes in exogenous variables irrespective of the true underlying functional forms.

Piggott(1992) also pointed out that, econometric models also have the weakness of providing only approximations. EDM ignores paths of adjustment from one equilibrium position to another, because procedures really amount to comparative static analysis. This problem may be solved by repeated applications using elasticities corresponding to different lengths of run.

2.2 Comparative Statics

Consider a homogeneous single commodity market, say, pork in China. We assume that meat accounts for a sufficiently small share of the domestic economy such that consumer income can be treated as exogenous. The Chinese government imposes an *ad valorem* subsidy when consumers purchase pork (price subsidy), which is assumed to equal θ. More assumptions are set as follows:

a) Closed economy (no trade with outer world);

b) Perfect competition (buyers and sellers are both price takers);

c) Meat accounts for a sufficiently small share of the domestic economy such that consumer income Y can be treated as exogenous;

d) Demand is downward sloping, and supply is upward sloping.

With these assumptions, let the initial equilibrium for this commodity market be defined as the following structural model:

$$\text{Urban Demand:} \qquad Q^U = D^U(P^U, Y) \tag{2.1}$$

$$\text{Rural Demand:} \qquad Q^R = D^R(P^R, Y) \tag{2.2}$$

$$\text{Domestic Supply:} \qquad Q^S = S(P^S) \tag{2.3}$$

$$\text{Price Transmission:} \qquad (1+\theta)P^U = W^U(P^S) \tag{2.4}$$

$$(1+\theta)P^R = W^R(P^S) \tag{2.5}$$

$$\text{Market Clearing:} \qquad Q^S = Q^U + Q^R \tag{2.6}$$

where θ denotes the percentage of price subsidy, and we set $Z = (1 + \theta)$ as the subsidy "wedge". For prices (P) as well as demand quantities, consumer income (Y), superscripts denote the location where the meat is consumed, while U represents urban market, and R means rural. P^S is supply price at the farm level, which is lower than the retail price of both urban and rural, due to marketing cost.

As shown in equation (2.1) and (2.2), the demand market is divided into two segments: the urban (U) and the rural (R), since the price transmission processes are different between urban and rural. This segmentation allows for market-specific responses to price and income growth, and permits analysis of the policy intervention in the market. The two price transmission equations (2.4) and (2.5) link the wholesale markets to the farm market, and show how the price subsidy works when consumers buy the product. The supply equation defines the total production at the farm level. The model is closed by equation (2.6), which equates the domestic production with the sum of consumptions in the urban and rural market, since the market is assumed as a closed economy, all imports and exports are omitted. Our key interest is the effects of income growth and the subsidy.

To address this issue, we first write the model in equilibrium displacement form, the above system may be expressed in terms of percentage changes as follows:

$$EQ^U = -\eta^U EP^U + \delta^U EY \tag{2.7}$$

$$EQ^R = -\eta^R EP^R + \delta^R EY \tag{2.8}$$

$$EQ^S = \varepsilon EP^S \tag{2.9}$$

$$EP^U + EZ = \omega^U EP^S \tag{2.10}$$

$$EP^U + EZ = \omega^R EP^S \tag{2.11}$$

$$EQ^S = k^U EQ^U + k^R Q^R \tag{2.12}$$

where the E indicate relative change variables ($EX = \frac{dX}{X}$); $k^U = \frac{Q^U}{Q^R + Q^U}$ is the share vector of urban consumption from the domestic supply, $k^R = \frac{Q^R}{Q^R + Q^U}$ is the share vector of rural consumption from the domestic supply. $\eta(> 0)$ is the absolute value of the urban or rural demand elasticities vector, $\varepsilon(> 0)$ is the domestic supply elasticities vector, $\omega(0 < \omega < 1)$ is the urban/rural price transmission elasticity. And $\delta(> 0)$ is the urban or rural income elasticity.

The comparative static results with respect to prices are obtained by setting the relative change of total supply (equation (2.9)) equal to the percentage sum of relative change in urban demand (equation (2.6)) and rural demand (equation (2.7)) under the equilibrium circumstance, and making use of price linkages (equations (2.10) and (2.11)), to yield the following equations:

$$EP^S = \frac{k^U\delta^U + k^R\delta^R}{\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R}EY + \frac{k^U\eta^U + k^R\eta^R}{\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R}EZ \tag{2.13}$$

$$EP^U = \frac{\omega^U(k^U\delta^U + k^R\delta^R)}{\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R}EY + \frac{k^R\eta^R(\omega^U - \omega^R) - \varepsilon}{\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R}EZ \tag{2.14}$$

$$EP^R = \frac{\omega^R(k^U\delta^U + k^R\delta^R)}{\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R}EY + \frac{-k^U\eta^U(\omega^U - \omega^R) - \varepsilon}{\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R}EZ \tag{2.15}$$

According to equations (2.13) – (2.15), income growth affects all prices in the same positive direction, and the ratio of the relative change of prices at each market with respect to income growth is equal to their price transmission elasticities ratio, that is, $\frac{EP^S}{EY} : \frac{EP^U}{EY} : \frac{EP^R}{EY} = 1 : \omega^U : \omega^R$. For simplicity, we set $\delta = (k^U\delta^U + k^R\delta^R)$ as the overall income elasticity, and $\eta = (k^U\omega^U\eta^U + k^R\omega^R\eta^R)$ as the absolute value of overall demand elasticity.

An increase in the price subsidy causes much more complicated effects. The only certainty is that producers would benefit under the subsidy circumstance ($\frac{EP^S}{EZ} > 0$). However, the consumers' welfare depends on the values of several parameters. For example, the urban consumers would suffer loss if $[k^R\eta^R(\omega^U - \omega^R) - \varepsilon] > 0$, in this case, $\frac{EP^U}{EZ} > 0$. Moreover, if

$\omega^U = \omega^R$, both the urban and rural consumers would gain since both demand prices would fall, and at an equal ratio ($\frac{EP^U}{EY} = \frac{EP^R}{EY} = -\frac{\varepsilon}{\eta+\varepsilon} < 0$).

If the supply side is perfectly elastic ($\varepsilon = \infty$), $\frac{EP^S}{EY} = \frac{EP^U}{EY} = \frac{EP^R}{EY} = 0$, which implies that the income effect on prices could be neglected, as well as the subsidy effect on producers ($\frac{EP^S}{EZ} = 0$). Then the consumers enjoy all the subsidy benefit, as would tend to be true according to the principle that the less elastic side of the market bears the greater incidence of subsidy.

Conversely, if the domestic supply is fixed ($\varepsilon = 0$), say, in the "short-run" period (one year or less), Equations (2.13) – (2.15) reduce to:

$$EP^S = \frac{k^U\delta^U + k^R\delta^R}{k^U\omega^U\eta^U + k^R\omega^R\eta^R}EY + \frac{k^U\eta^U + k^R\eta^R}{k^U\omega^U\eta^U + k^R\omega^R\eta^R}EZ \tag{2.16}$$
$$EP^U = \frac{\omega^U(k^U\delta^U + k^R\delta^R)}{k^U\omega^U\eta^U + k^R\omega^R\eta^R}EY + \frac{k^R\eta^R(\omega^U - \omega^R)}{k^U\omega^U\eta^U + k^R\omega^R\eta^R}EZ \tag{2.17}$$
$$EP^R = \frac{\omega^R(k^U\delta^U + k^R\delta^R)}{k^U\omega^U\eta^U + k^R\omega^R\eta^R}EY + \frac{-k^U\eta^U(\omega^U - \omega^R)}{k^U\omega^U\eta^U + k^R\omega^R\eta^R}EZ \tag{2.18}$$

In this case, the price effect of income growth on supply would be elastic ($\frac{EP^S}{EY} > 1$) only if $\delta > \eta$. However, the homogeneity condition indicates that in most cases, an estimate of the income elasticity would give us a lower limit to the absolutely value of own-price elasticity ($\delta \leq \eta$), since substitution among commodities is more common than complementarity. Then, the price effects of income growth on urban and rural demand are both inelastic ($\frac{EP^U}{EY} < 1$ and $\frac{EP^R}{EY} < 1$), since the urban/rural "market-based income elasticity" is always less than the overall demand elasticity ($0 < \omega\delta < \delta < \eta$, for $0 < \omega < 1$). The subsidy effects on demand prices are uncertain, but in this case we know that the urban and rural consumers would receive opposite effects. For common cases in reality, the urban price transmission elasticity is less than the rural one ($\omega^U < \omega^R$), then an increase in the subsidy would cause a rise in rural price and meanwhile a fall in urban price, that is, the rural consumers would suffer loss while the urban consumers gain from the subsidy, as the producer would definitely enjoy most of the benefit, no matter how the values of parameters vary. Things are clear if we set ($\omega^U = \omega^R$), neither the urban nor the rural consumers would gain($\frac{EP^U}{EZ} = \frac{EP^R}{EZ} = 0$), and the producers receive all the benefit. Again, this is additional evidence that the less elastic side of the market bears the greater incidence of subsidy.

The comparative static results for quantities are obtained by substituting equations (2.13) – (2.15) back, and to yield Equations (2.19) – (2.21):

$$EQ^S = \frac{\varepsilon(k^U\delta^U + k^R\delta^R)}{(\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R)}EY + \frac{\varepsilon(k^U\eta^U + k^R\eta^R)}{(\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R)}EZ \tag{2.19}$$

$$EQ^U = \frac{-k^R(\omega^U\eta^U\delta^R - \omega^R\eta^R\delta^U) + \delta^U\varepsilon}{(\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R)}EY + \frac{\eta^U[-k^R\eta^R(\omega^U - \omega^R) + \varepsilon]}{(\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R)}EZ \tag{2.20}$$

$$EQ^R = \frac{k^U(\omega^U\eta^U\delta^R - \omega^R\eta^R\delta^U) + \delta^R\varepsilon}{(\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R)}EY + \frac{\eta^R[k^U\eta^U(\omega^U - \omega^R) + \varepsilon]}{(\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R)}EZ \tag{2.21}$$

From equations (2.19) – (2.21), income growth would increase the quantity of total consumption, which is equal to the quantity of supply($\frac{EQ^S}{EY} > 0$), and the subsidy would have the same results($\frac{EQ^S}{EZ} > 0$). If the domestic supply is fixed ($\varepsilon = 0$), both the income growth effects and subsidy effects upon supply quantity are zero ($\frac{EQ^S}{EY} = 0$ and $\frac{EQ^S}{EZ} > 0$). In this case, the subsidy has opposite effects on urban and rural consumption, for it is obvious that $\frac{EQ^U}{EZ} = -\frac{k^R\eta^U\eta^R(\omega^U - \omega^R)}{\varepsilon + \eta}$ and $\frac{EQ^R}{EZ} = \frac{k^U\eta^U\eta^R(\omega^U - \omega^R)}{\varepsilon + \eta}$ have opposite signs. If $\omega^U > \omega^R$, then $\frac{EQ^U}{EZ} < 0$ and $\frac{EQ^R}{EZ} > 0$, that is, a rise in the subsidy would decrease the urban consumption and increase the rural consumption, and in all, has no effect on the total consumption, which equals to the total supply. Moreover, if $\omega^U = \omega^R$, all of the subsidy effects on quantities become nil ($\frac{EQ^S}{EZ} = \frac{EQ^U}{EZ} = \frac{EQ^R}{EZ} = 0$).

The total responses of quantities to income growth are never greater than the partial ones, this result is seen by returning to Equation (2.19) and setting $EZ = 0$, we rewrite the first equation as:

$$EQ^S = \delta^T EY \tag{2.22}$$

where $\delta^T = \dfrac{(k^U\delta^U + k^R\delta^R)\varepsilon}{(\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R)}$ is the "total" demand elasticity with respect to income (Kinnucan and Myrland. 2005). Since $\dfrac{\varepsilon}{(\varepsilon + k^U\omega^U\eta^U + k^R\omega^R\eta^R)} \leq 1$, it follows that $\delta^T \leq (k^U\delta^U + k^R\delta^R) = \delta$, which denotes that the partial income elasticity sets the upper limit on the total elasticity. That is, in most cases such that $\varepsilon < \infty$, the income elasticity that takes into account induced price effects will always be smaller than the income elasticity that treats price as constant.

2.3 A Two Commodity Market

Consider a competitive market for commodities that are interrelated on the demand side. The most concise way is to establish a model in the market with two commodities. Moreover, for simplicity, we set all price transmission elasticities equal to 1, which implies that the producers and all consumers would take the same prices for a commodity. Initial equilibrium is then indicated by the following structural model:

$$\text{Demands:} \qquad Q_1^D = D_1(P_1, P_2, Y) \tag{2.23}$$

$$Q_2^D = D_2(P_1, P_2, Y) \tag{2.24}$$

$$\text{Supplies:} \qquad Q_1^S = S_1(P_1) \tag{2.25}$$

$$Q_2^S = S_2(P_2) \tag{2.26}$$

$$\text{Market Clearing:} \qquad Q_1^D = Q_1^S \tag{2.27}$$

$$Q_2^D = Q_2^S \tag{2.28}$$

where the superscript D denotes the demand market, while superscript S denotes the supply market, and subscript numbers denote the two different kind of commodities, for prices (P) and demand quantities (Q), and Y denotes the income. The model may be expressed in

EDM form as follows:

$$EQ_1^D = \eta_{11}EP_1 + \eta_{12}EP_2 + \delta_1 EY \tag{2.29}$$

$$EQ_2^D = \eta_{21}EP_1 + \eta_{22}EP_2 + \delta_2 EY \tag{2.30}$$

$$EQ_1^S = \varepsilon_1 EP_1 \tag{2.31}$$

$$EQ_2^S = \varepsilon_2 EP_2 \tag{2.32}$$

$$EQ_1^D = EQ_1^S \tag{2.33}$$

$$EQ_2^D = EQ_2^S \tag{2.34}$$

The parameter η_{ii} (< 0) is the value of the demand elasticity of its own-price, while the cross-price elasticity, η_{ij} $(i \neq j)$, capture the substitution of i that occurs when the price of commodity j changes. δ_i denotes the income elasticity of commodity i, and ε_i is its supply price elasticity. Substituting Equations (2.29) – (2.32) into Equation (2.33) and (2.34) yields the following matrix–representation of market equilibrium:

$$\begin{pmatrix} \varepsilon_1 & 0 \\ 0 & \varepsilon_2 \end{pmatrix} \begin{pmatrix} EP_1 \\ EP_2 \end{pmatrix} = \begin{pmatrix} \eta_{11} & \eta_{12} \\ \eta_{21} & \eta_{22} \end{pmatrix} \begin{pmatrix} EP_1 \\ EP_2 \end{pmatrix} + \begin{pmatrix} \delta_1 \\ \delta_2 \end{pmatrix} EY$$

We put the exogenous variables to one side, and the endogenous variable to the other, and solve the equation for the relative change $\frac{\mathbf{EP}}{EY}$, then rewrite it as:

$$\begin{aligned} \frac{\mathbf{EP}}{EY} &= \left[\begin{pmatrix} \varepsilon_1 & 0 \\ 0 & \varepsilon_2 \end{pmatrix} - \begin{pmatrix} \eta_{11} & \eta_{12} \\ \eta_{21} & \eta_{22} \end{pmatrix} \right]^{-1} \begin{pmatrix} \delta_1 \\ \delta_2 \end{pmatrix} = \begin{pmatrix} \varepsilon_1 - \eta_{11} & -\eta_{12} \\ -\eta_{21} & \varepsilon_2 - \eta_{22} \end{pmatrix}^{-1} \begin{pmatrix} \delta_1 \\ \delta_2 \end{pmatrix} \\ &= \frac{1}{(\varepsilon_1 - \eta_{11})(\varepsilon_2 - \eta_{22}) - \eta_{12}\eta_{21}} \begin{pmatrix} (\varepsilon_2 - \eta_{22})\delta_1 + \eta_{21}\delta_2 \\ (\varepsilon_1 - \eta_{11})\delta_2 + \eta_{12}\delta_1 \end{pmatrix} \end{aligned} \tag{2.35}$$

We have already set η_{ii} as negative, so $(\varepsilon_i - \eta_{ii})$is identically greater than zero. The comparative statics result is showed in Equation (2.35). In most cases, $\frac{EP_i}{EY}$ would be positive, as we expected, the prices would rise as income grows, and so would the quantities do. However, the signs of the relative changes of prices to income would be influenced by other parameters, $\frac{EP_i}{EY}$ has several possibilities to have negative values, which means the prices would drop even if there is an income growth. This effect is counter-intuitive, and thus deserves further analysis:

a) If the two commodities are both substitutes for each other, that is, both of the cross-price demand elasticities are positive ($\eta_{12} > 0$ and $\eta_{21} > 0$), then the prices would definitely rise as income grows ($\frac{EP_i}{EY} > 0$), for $(\varepsilon_1 - \eta_{11})(\varepsilon_2 - \eta_{22}) > \eta_{12}\eta_{21}$ is always true. It is the homogeneity condition ensures that the absolute value of a commodity's own price elasticity to be greater than that of its cross price elasticities ($\eta_{12} = -\eta_{11} - \delta_1 < -\eta_{11}$ and $\eta_{21} = -\eta_{22} - \delta_2 < -\eta_{22}$) in this case.

b) If only one of the cross-price demand elasticities is negative, in this case, $(\varepsilon_1 - \eta_{11})(\varepsilon_2 - \eta_{22}) - \eta_{12}\eta_{21} > 0$ would definitely be true again, then $\frac{EP_i}{EY}$ would be negative only if $\frac{\delta_i}{\delta_j} < \frac{\varepsilon_i - \eta_{ii}}{-\eta_{ij}}$ (for $\eta_{ij} < 0$ and $\eta_{ji} > 0$). This could happen if the difference between "partial" income elasticities of different commodities is big enough, or, if complementary (negative) cross-commodity effect is sufficiently large. Note the homogeneity condition no longer ensures $|\eta_{ii}| > |\eta_{ij}|$ if there is complementary effect for the commodity i.

c) If the two commodities are both complements for each other, that is, η_{21} and η_{12} are both negative, then $\frac{EP_i}{EY}$ could be negative when: $(\varepsilon_1 - \eta_{11})(\varepsilon_2 - \eta_{22}) > \eta_{12}\eta_{21}$ while $\frac{\delta_i}{\delta_j} < \frac{\varepsilon_i - \eta_{ii}}{-\eta_{ij}}$; or $(\varepsilon_1 - \eta_{11})(\varepsilon_2 - \eta_{22}) < \eta_{12}\eta_{21}$ while $\frac{\delta_i}{\delta_j} > \frac{\varepsilon_i - \eta_{ii}}{-\eta_{ij}}$.

A severe "quasi–singularity" problem exists there. This problem occurs when the values of $(\varepsilon_1 - \eta_{11})(\varepsilon_2 - \eta_{22})$ and $\eta_{12}\eta_{21}$ are close enough, the results matrix tends to be singular, then $\frac{EP_i}{EY}$ could become very large numbers, which denotes that the prices are very sensitive to income growth, and both signs are very possible. Moreover, in this case, assume one of the parameters varies just a little bit, then the income growth might have totally different effect on prices — from infinity to an opposite infinity. Cross-price elasticities, even when they are small numbers, still could have an immense effect on demand and supply in the market. Mathematically, the result comes from the mechanics of matrix inverse, as shown in equation(2.35). For the function of EDM results (e.g. $\frac{EP_i}{EY}$) and cross-effect parameters, there is a turning point for each of the cross-commodity elasticity values, and the function would in the form of hyperbola curves (assume the cross-commodity elasticity endogenous, and other variables constant, temporarily).

If we ignore the cross-commodity effects, in this case, set $\eta_{12} = \eta_{21} = 0$, things become much easier. The comparative statics result would display clearly as:

$$\frac{\mathbf{EP}}{EY} = \begin{pmatrix} \dfrac{\delta_1}{(\varepsilon_1 - \eta_{11})} \\ \dfrac{\delta_2}{(\varepsilon_2 - \eta_{22})} \end{pmatrix} \tag{2.36}$$

Substituting equation (2.36) back to equation (2.31) and (2.32):

$$\frac{\mathbf{EQ}}{EY} = \begin{pmatrix} \dfrac{\varepsilon_1\delta_1}{(\varepsilon_1 - \eta_{11})} \\ \dfrac{\varepsilon_2\delta_2}{(\varepsilon_2 - \eta_{22})} \end{pmatrix} \tag{2.37}$$

which denotes the prices and quantities would increase as income grows. Moreover, from equation (2.37), it is explicit that the total income elasticity $\frac{EP}{EY}$ is always smaller than the partial one (δ), since $\frac{\varepsilon_i}{(\varepsilon_i - \eta_{ii})} < 1$, which conforms to the result in equation (2.22).

Chapter 3

Model

3.1 Equations System

The model is first developed for the consumer market in China. The domestic market is divided into two separated segments: urban and rural. Demands for meat are functions of the price of itself, as well as of the prices of other kinds of meat, since each meat is treated as substitute of other meats. Therefore, the proportional changes in China's meat demand are represented as:

Urban Demands:

$$
\begin{aligned}
EQ_1^U &= \eta_{11}^U EP_1^U + \eta_{12}^U EP_2^U + \eta_{13}^U EP_3^U + \eta_{14}^U EP_4^U + \eta_{15}^U EP_5^U + \delta_1^U EY^U \\
EQ_2^U &= \eta_{21}^U EP_1^U + \eta_{22}^U EP_2^U + \eta_{23}^U EP_3^U + \eta_{24}^U EP_4^U + \eta_{25}^U EP_5^U + \delta_2^U EY^U \\
EQ_3^U &= \eta_{31}^U EP_1^U + \eta_{32}^U EP_2^U + \eta_{33}^U EP_3^U + \eta_{34}^U EP_4^U + \eta_{35}^U EP_5^U + \delta_3^U EY^U \\
EQ_4^U &= \eta_{41}^U EP_1^U + \eta_{42}^U EP_2^U + \eta_{43}^U EP_3^U + \eta_{44}^U EP_4^U + \eta_{45}^U EP_5^U + \delta_4^U EY^U \\
EQ_5^U &= \eta_{51}^U EP_1^U + \eta_{52}^U EP_2^U + \eta_{53}^U EP_3^U + \eta_{54}^U EP_4^U + \eta_{55}^U EP_5^U + \delta_5^U EY^U
\end{aligned}
\tag{3.1}
$$

Rural Demands:

$$
\begin{aligned}
EQ_1^R &= \eta_{11}^R EP_1^R + \eta_{12}^R EP_2^R + \eta_{13}^R EP_3^R + \eta_{14}^R EP_4^R + \eta_{15}^R EP_5^R + \delta_1^R EY^R \\
EQ_2^R &= \eta_{21}^R EP_1^R + \eta_{22}^R EP_2^R + \eta_{23}^R EP_3^R + \eta_{24}^R EP_4^R + \eta_{25}^R EP_5^R + \delta_2^R EY^R \\
EQ_3^R &= \eta_{31}^R EP_1^R + \eta_{32}^R EP_2^R + \eta_{33}^R EP_3^R + \eta_{34}^R EP_4^R + \eta_{35}^R EP_5^R + \delta_3^R EY^R \\
EQ_4^R &= \eta_{41}^R EP_1^R + \eta_{42}^R EP_2^R + \eta_{43}^R EP_3^R + \eta_{44}^R EP_4^R + \eta_{45}^R EP_5^R + \delta_4^R EY^R \\
EQ_5^R &= \eta_{51}^R EP_1^R + \eta_{52}^R EP_2^R + \eta_{53}^R EP_3^R + \eta_{54}^R EP_4^R + \eta_{55}^R EP_5^R + \delta_5^R EY^R
\end{aligned}
\tag{3.2}
$$

The operator $E(X) = \frac{dX}{X} = d\log(X)$ is used to represent proportional changes. For prices (P) and demand quantities (Q), as well as income (Y), superscripts denote the location where the meat is consumed, while U represents urban market, and R represents rural; and subscript numbers denote the what kind of meat it is: $1 =$ *Pork*, $2 =$ *Poultry*, $3 =$ *Beef*, $4 =$ *Mutton*, and $5 =$ *Aquatic Products (AP)*. The parameter $\eta_{ii}(< 0)$ is the value of the demand elasticity of its own-price, and the cross-price elasticity, η_{ij} (ij), capture the substitution of i that occurs when the price of meat j changes. And $\delta_i(> 0)$ denotes the income elasticity.

Domestic Supplies:

Proportional changes in the supply quantities are function of the change in supply prices, represented as:

$$\begin{aligned} EQ_1^S &= \varepsilon_1 EP_1^S \\ EQ_2^S &= \varepsilon_2 EP_2^S \\ EQ_3^S &= \varepsilon_3 EP_3^S \\ EQ_4^S &= \varepsilon_4 EP_4^S \\ EQ_5^S &= \varepsilon_5 EP_5^S \end{aligned} \tag{3.3}$$

where ε_i denotes the supply price elasticity of meat i. P_i^S is the price of meat i in the farm level, and Q_i^S is the total supply quantity of meat i in the domestic market.

Price Transmission:

$$
\begin{aligned}
&EP_1^U + EZ = \omega_1^U EP_1^S \\
&EP_2^U = \omega_2^U EP_2^S \\
&EP_3^U = \omega_3^U EP_3^S \\
&EP_4^U = \omega_4^U EP_4^S \\
&EP_5^U = \omega_5^U EP_5^S \\
&EP_1^R + EZ = \omega_1^R EP_1^S \\
&EP_2^R = \omega_2^R EP_2^S \\
&EP_3^R = \omega_3^R EP_3^S \\
&EP_4^R = \omega_4^R EP_4^S \\
&EP_5^R = \omega_5^R EP_5^S
\end{aligned}
\tag{3.4}
$$

Market Equilibriums:

Assuming equilibrium in the meat markets, because the total domestic supply is equal to the sum of urban and rural markets, in term of proportional changes, this implies:

$$
\begin{aligned}
&k_1^U EQ_1^U + k_1^R EQ_1^R = EQ_1^S \\
&k_2^U EQ_2^U + k_2^R EQ_2^R = EQ_2^S \\
&k_3^U EQ_3^U + k_3^R EQ_3^R = EQ_3^S \\
&k_4^U EQ_4^U + k_4^R EQ_4^R = EQ_4^S \\
&k_5^U EQ_5^U + k_5^R EQ_5^R = EQ_5^S
\end{aligned}
\tag{3.5}
$$

where k_i^U is the proportion of urban market proportion of meat i, while $k_i^R = (1 - k_i^U)$ is the proportion of rural market proportion of meat i.

The definitions of all parameters in this EDM model are shown in table 4.1.

3.2 Matrix Form

Substituting Equations (3.1)–(3.4) into Equations (3.5) yields the following matrix representation of market equilibrium:

$$
\begin{aligned}
&\begin{pmatrix} \varepsilon_1 & 0 & 0 & 0 & 0 \\ 0 & \varepsilon_2 & 0 & 0 & 0 \\ 0 & 0 & \varepsilon_3 & 0 & 0 \\ 0 & 0 & 0 & \varepsilon_4 & 0 \\ 0 & 0 & 0 & 0 & \varepsilon_5 \end{pmatrix}
\begin{pmatrix} EP_1^S \\ EP_2^S \\ EP_3^S \\ EP_4^S \\ EP_5^S \end{pmatrix} = \\
&\quad \begin{pmatrix} k_1^R & 0 & 0 & 0 & 0 \\ 0 & k_2^R & 0 & 0 & 0 \\ 0 & 0 & k_3^R & 0 & 0 \\ 0 & 0 & 0 & k_4^R & 0 \\ 0 & 0 & 0 & 0 & k_5^R \end{pmatrix}
\begin{pmatrix} \eta_{11}^R & \eta_{12}^R & \eta_{13}^R & \eta_{14}^R & \eta_{15}^R \\ \eta_{21}^R & \eta_{22}^R & \eta_{23}^R & \eta_{24}^R & \eta_{25}^R \\ \eta_{31}^R & \eta_{32}^R & \eta_{33}^R & \eta_{34}^R & \eta_{35}^R \\ \eta_{41}^R & \eta_{42}^R & \eta_{43}^R & \eta_{44}^R & \eta_{45}^R \\ \eta_{51}^R & \eta_{52}^R & \eta_{53}^R & \eta_{54}^R & \eta_{55}^R \end{pmatrix}
\begin{pmatrix} \omega_1^R & 0 & 0 & 0 & 0 \\ 0 & \omega_2^R & 0 & 0 & 0 \\ 0 & 0 & \omega_3^R & 0 & 0 \\ 0 & 0 & 0 & \omega_4^R & 0 \\ 0 & 0 & 0 & 0 & \omega_5 \end{pmatrix}
\begin{pmatrix} EP_1^S \\ EP_2^S \\ EP_3^S \\ EP_4^S \\ EP_5^S \end{pmatrix} \\
&- \begin{pmatrix} k_1^R & 0 & 0 & 0 & 0 \\ 0 & k_2^R & 0 & 0 & 0 \\ 0 & 0 & k_3^R & 0 & 0 \\ 0 & 0 & 0 & k_4^R & 0 \\ 0 & 0 & 0 & 0 & k_5^R \end{pmatrix}
\begin{pmatrix} \eta_{11}^R & \eta_{12}^R & \eta_{13}^R & \eta_{14}^R & \eta_{15}^R \\ \eta_{21}^R & \eta_{22}^R & \eta_{23}^R & \eta_{24}^R & \eta_{25}^R \\ \eta_{31}^R & \eta_{32}^R & \eta_{33}^R & \eta_{34}^R & \eta_{35}^R \\ \eta_{41}^R & \eta_{42}^R & \eta_{43}^R & \eta_{44}^R & \eta_{45}^R \\ \eta_{51}^R & \eta_{52}^R & \eta_{53}^R & \eta_{54}^R & \eta_{55}^R \end{pmatrix}
\begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} EZ +
\begin{pmatrix} k_1^R & 0 & 0 & 0 & 0 \\ 0 & k_2^R & 0 & 0 & 0 \\ 0 & 0 & k_3^R & 0 & 0 \\ 0 & 0 & 0 & k_4^R & 0 \\ 0 & 0 & 0 & 0 & k_5^R \end{pmatrix}
\begin{pmatrix} \delta_1^R \\ \delta_2^R \\ \delta_3^R \\ \delta_4^R \\ \delta_5^R \end{pmatrix} EY \\
&+ \begin{pmatrix} k_1^U & 0 & 0 & 0 & 0 \\ 0 & k_2^U & 0 & 0 & 0 \\ 0 & 0 & k_3^U & 0 & 0 \\ 0 & 0 & 0 & k_4^U & 0 \\ 0 & 0 & 0 & 0 & k_5^U \end{pmatrix}
\begin{pmatrix} \eta_{11}^U & \eta_{12}^U & \eta_{13}^U & \eta_{14}^U & \eta_{15}^U \\ \eta_{21}^U & \eta_{22}^U & \eta_{23}^U & \eta_{24}^U & \eta_{25}^U \\ \eta_{31}^U & \eta_{32}^U & \eta_{33}^U & \eta_{34}^U & \eta_{35}^U \\ \eta_{41}^U & \eta_{42}^U & \eta_{43}^U & \eta_{44}^U & \eta_{45}^U \\ \eta_{51}^U & \eta_{52}^U & \eta_{53}^U & \eta_{54}^U & \eta_{55}^U \end{pmatrix}
\begin{pmatrix} \omega_1^U & 0 & 0 & 0 & 0 \\ 0 & \omega_2^U & 0 & 0 & 0 \\ 0 & 0 & \omega_3^U & 0 & 0 \\ 0 & 0 & 0 & \omega_4^U & 0 \\ 0 & 0 & 0 & 0 & \omega_5^U \end{pmatrix}
\begin{pmatrix} EP_1^S \\ EP_2^S \\ EP_3^S \\ EP_4^S \\ EP_5^S \end{pmatrix} \\
&- \begin{pmatrix} k_1^U & 0 & 0 & 0 & 0 \\ 0 & k_2^U & 0 & 0 & 0 \\ 0 & 0 & k_3^U & 0 & 0 \\ 0 & 0 & 0 & k_4^U & 0 \\ 0 & 0 & 0 & 0 & k_5^U \end{pmatrix}
\begin{pmatrix} \eta_{11}^U & \eta_{12}^U & \eta_{13}^U & \eta_{14}^U & \eta_{15}^U \\ \eta_{21}^U & \eta_{22}^U & \eta_{23}^U & \eta_{24}^U & \eta_{25}^U \\ \eta_{31}^U & \eta_{32}^U & \eta_{33}^U & \eta_{34}^U & \eta_{35}^U \\ \eta_{41}^U & \eta_{42}^U & \eta_{43}^U & \eta_{44}^U & \eta_{45}^U \\ \eta_{51}^U & \eta_{52}^U & \eta_{53}^U & \eta_{54}^U & \eta_{55}^U \end{pmatrix}
\begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} EZ +
\begin{pmatrix} k_1^U & 0 & 0 & 0 & 0 \\ 0 & k_2^U & 0 & 0 & 0 \\ 0 & 0 & k_3^U & 0 & 0 \\ 0 & 0 & 0 & k_4^U & 0 \\ 0 & 0 & 0 & 0 & k_5^U \end{pmatrix}
\begin{pmatrix} \delta_1^U \\ \delta_2^U \\ \delta_3^U \\ \delta_4^U \\ \delta_5^U \end{pmatrix} EY
\end{aligned}
\tag{3.6}
$$

The right-hand side of Equation (3.6) indicates the influences of demand side and marketing forces on market equilibrium, and the left-hand side reflects supply side influences. Denoting the diagonal matrix of shares as $\mathbf{K}$; the square matrix of demand price elasticities as $\mathbf{N}$; the diagonal matrix of price transmission elasticities as $\mathbf{W}$; the diagonal matrix of supply price elasticities as $\mathbf{B}$; the vector of demand elasticities with respect to price of pork as $\mathbf{N_1}$, which is also the first column of the square matrix $\mathbf{N}$; the vector of income elasticities as $\mathbf{A}$; and vector $\boldsymbol{\lambda} = [1,\, 0,\, 0,\, 0,\, 0]^{-1}$. Equation (3.6) could then be expressed symbolically as:

$$\begin{aligned}\mathbf{B} \times \mathbf{EP^S} =& (\mathbf{K^R} \times \mathbf{N^R} \times \mathbf{W^R} \times \mathbf{EP^S} - \mathbf{K^R} \times \mathbf{N^R} \times \boldsymbol{\lambda} \times EZ + \mathbf{K^R} \times \mathbf{A^R} \times EY) \\ &+ (\mathbf{K^U} \times \mathbf{N^U} \times \mathbf{W^U} \times \mathbf{EP^S} - \mathbf{K^U} \times \mathbf{N^U} \times \boldsymbol{\lambda} \times EZ + \mathbf{K^U} \times \mathbf{A^U} \times EY)\end{aligned} \tag{3.7}$$

where $\mathbf{EP^S}$ is the vector of supply price changes. We put the exogenous variables to one side, and the endogenous variable to the other:

$$(\mathbf{B} - \mathbf{K^R N^R W^R} - \mathbf{K^U N^U W^U})\mathbf{EP^S} = (\mathbf{K^R A^R} + \mathbf{K^U A^U})EY - \left[(\mathbf{K^R N^R} + \mathbf{K^U N^U})\boldsymbol{\lambda}\right] EZ$$

The reduced form for supply price changes now could be obtained by premultiplying $(\mathbf{B} - \mathbf{K^R N^R W^R} - \mathbf{K^U N^U W^U})^{-\mathbf{1}}$:

$$\begin{aligned}\mathbf{EP^S} =& (\mathbf{B} - \mathbf{K^R N^R W^R} - \mathbf{K^U N^U W^U})^{-1}(\mathbf{K^R A^R} + \mathbf{K^U A^U}) \times EY \\ &- (\mathbf{B} - \mathbf{K^R N^R W^R} - \mathbf{K^U N^U W^U})^{-1}(\mathbf{K^R N^R} + \mathbf{K^U N^U})\boldsymbol{\lambda} \times EZ\end{aligned} \tag{3.8}$$

which can be written more compactly as:

$$\mathbf{EP^S} = \mathbf{F} \times EY - \mathbf{G} \times EZ \tag{3.9}$$

where $\mathbf{F}$ and $\mathbf{G}$ are 5×1 vectors of reduced form coefficients associated with EY. Equation (3.9) measures the net effect of increases in income and price subsidy on supply prices, taking into account cross-commodity substitution and supply response. The corresponding net impacts on urban and rural prices and quantities are obtained through back substitution of Equation (3.9) into Equation (3.3) and (3.4).

For urban prices:

$$\begin{pmatrix} EP_1^U \\ EP_2^U \\ EP_3^U \\ EP_4^U \\ EP_5^U \end{pmatrix} = \begin{pmatrix} \omega_1^U & 0 & 0 & 0 & 0 \\ 0 & \omega_2^U & 0 & 0 & 0 \\ 0 & 0 & \omega_3^U & 0 & 0 \\ 0 & 0 & 0 & \omega_4^U & 0 \\ 0 & 0 & 0 & 0 & \omega_5^U \end{pmatrix} \cdot \begin{pmatrix} EP_1^S \\ EP_2^S \\ EP_3^S \\ EP_4^S \\ EP_5^S \end{pmatrix} - \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \cdot EZ \tag{3.10}$$

Or in symbolic matrix form:

$$\begin{aligned} \mathbf{EP^U} = \mathbf{W^U} \times \mathbf{EP^S} - \boldsymbol{\lambda} \times EZ &= (\mathbf{W^U} \times \mathbf{F}) \times EY - (\mathbf{W^U} \times \mathbf{G} + \boldsymbol{\lambda}) \times EZ \\ &= \mathbf{F^U} \times EY - \mathbf{G^U} \times EZ \end{aligned} \tag{3.11}$$

where $\mathbf{F^U} = (\mathbf{W^U} \times \mathbf{F})$, and $\mathbf{G^U} = (\mathbf{W^U} \times \mathbf{G} + \boldsymbol{\lambda})$. They are also 5×1 vectors of reduced form coefficients associated with EY, and measure the net effects of increases in income and price subsidy on urban demand prices, taking into account cross-commodity substitution and supply response.

For rural prices:

$$\begin{pmatrix} EP_1^R \\ EP_2^R \\ EP_3^R \\ EP_4^R \\ EP_5^R \end{pmatrix} = \begin{pmatrix} \omega_1^R & 0 & 0 & 0 & 0 \\ 0 & \omega_2^R & 0 & 0 & 0 \\ 0 & 0 & \omega_3^R & 0 & 0 \\ 0 & 0 & 0 & \omega_4^R & 0 \\ 0 & 0 & 0 & 0 & \omega_5^R \end{pmatrix} \cdot \begin{pmatrix} EP_1^S \\ EP_2^S \\ EP_3^S \\ EP_4^S \\ EP_5^S \end{pmatrix} - \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \cdot EZ \tag{3.12}$$

Or in symbolic matrix form,

$$\begin{aligned}\mathbf{EP^R} = \mathbf{W^R} \times \mathbf{EP^S} - \boldsymbol{\lambda} \times EZ = (\mathbf{W^R} \times \mathbf{F}) \times EY - (\mathbf{W^R} \times \mathbf{G} + \boldsymbol{\lambda}) \times EZ \\ = \mathbf{F^R} \times EY - \mathbf{G^R} \times EZ\end{aligned} \tag{3.13}$$

where $\mathbf{F^R} = (\mathbf{W^R} \times \mathbf{F})$, and $\mathbf{G^R} = (\mathbf{W^R} \times \mathbf{G} + \boldsymbol{\lambda})$.

For supply quantities:

$$\mathbf{EQ^S} = \mathbf{B} \times \mathbf{EP^S} = (\mathbf{B} \times \mathbf{F}) \times EY - (\mathbf{B} \times \mathbf{G}) \times EZ \tag{3.14}$$

For urban demand quantities:

$$\begin{aligned}\mathbf{EQ^U} &= \mathbf{N^U} \times \mathbf{EP^U} + \mathbf{A^U} \times EY \\ &= (\mathbf{N^U} \times \mathbf{F^U} + \mathbf{A^U}) \times EY - (\mathbf{N^U} \times \mathbf{G^U}) \times EZ\end{aligned} \tag{3.15}$$

For rural demand quantities:

$$\begin{aligned}\mathbf{EQ^R} &= \mathbf{N^R} \times \mathbf{EP^R} + \mathbf{A^R} \times EY \\ &= (\mathbf{N^R} \times \mathbf{F^R} + \mathbf{A^R}) \times EY - (\mathbf{N^R} \times \mathbf{G^R}) \times EZ\end{aligned} \tag{3.16}$$

Chapter 4

Parameterization

In most cases, few of the elasticities are estimated directly in studies of commodity market and policies, and it might also be not sensible simply to take elasticities from the literature. Instead, relevant elasticities are "guestimated" using a combination of results in the literature, economic theory, and intuition (James and Alston, 2002). Some economists believe that the econometrically estimated elasticities are intrinsically more accurate and otherwise superior to "guestimated" elasticities of the sort typically used in applied policy analysis, but econometric estimates have their own drawbacks, such as implausible magnitudes, wrong signs, and inconsistencies with economic theory. At least these deficiencies could be avoided in the introspective, or "guestimated" approach. Sometimes we "have to rely on a few estimates from the literature and introspection" (Fischer, 1986).

In this study, most of the necessary parameter estimates are collected from past analysis of the meat market in China, while the remaining parameters not found in past studies are 'guestimated'. All of the parameter values and sources are discussed below.

Table 4.1: Parameter Definitions

Item	Definition
η_{ii}^{U}	Own-price demand elasticities of Urban
η_{ii}^{R}	Own-price demand elasticities of Rural
η_{ij}^{U}	Cross-price demand elasticities of Urban
η_{ij}^{R}	Cross-price demand elasticities of Rural
δ_{i}^{U}	Income elasticities of Urban
δ_{i}^{R}	Income elasticities of Rural
k_{i}^{U}	Urban Demand Quantity Shares
k_{i}^{R}	Rural Demand Quantity Shares

Table 4.2: Urban and Rural Population and Per Capital Meat Consumption

	2005	2006	2007	2008
Urban Population [a]	526702880	541451260	556147470	570926305
Rural Population [a]	777017120	769568740	761737530	753728695
Urban Pork Per Capital [b]	20.15	20.00	18.21	19.3
Rural Pork Per Capital [b]	14.63	15.46	13.37	12.5
Urban Poultry Per Capital [b]	8.97	8.34	9.66	10.00
Rural Poultry Per Capital [b]	3.67	3.51	3.86	4.40
Urban Beef Per Capital [b]	2.78	2.83	2.93	2.70
Rural Beef Per Capital [b]	1.00	1.07	1.01	1.10
Urban Mutton Per Capital [b]	0.93	0.95	1.00	0.90
Rural Mutton Per Capital [b]	0.47	0.50	0.55	0.50
Urban AP Per Capital [b]	12.6	12.95	14.20	15.00
Rural AP Per Capital [b]	4.94	5.01	5.36	5.20

Source: [a] World Bank; [b] USDA.

4.1 Demand Quantity Shares of Urban and Rural

$$\begin{aligned} \textit{Total Consumption} =&(\textit{Per capital Urban} \times \textit{Urban Population} \\ &+ \textit{Per capital Rural} \times \textit{Rural Population}) \end{aligned}$$

$$k^U = \frac{\textit{Per capital Urban} \times \textit{Urban Population}}{\textit{Total Consumption}} \tag{4.1}$$

$$k^R = \frac{\textit{Per capital Rural} \times \textit{Rural Population}}{\textit{Total Consumption}} \tag{4.2}$$

Estimates for demand quantity shares of urban and rural are obtained based on the data of domestic consumptions and population from USDA and World Bank respectively, for the period 2005-2008. By using equations (4.1) and (4.2), we obtained the values of quantity shares of urban and rural as shown in table 4.3.

Table 4.3: Urban & Rural Demand Quantity Shares

	Urban (k_i^U)	Rural (k_i^R)
Pork	0.50	0.50
Poultry	0.63	0.37
Beef	0.65	0.35
Mutton	0.57	0.43
AP	0.66	0.34

4.2 Consumption Demand Elasticities for Price and Expenditure

Pudney and Wang (1991) estimated that the own price elasticities of demand for pork (-0.04) and poultry (-0.005) in China. Their estimated income elasticities for pork and poultry were 0.923 and 0.716, respectively. Hsu et al (2002) estimated that the own price demand elasticities for pork (-1.59)and poultry(-1.28) for urban residents, and those for rural residents were -0.50 and -0.66, respectively. They also estimated income elasticities for pork(1.68) and poultry (3.12) for urban residents, and those for rural residents were 0.67 and 0.70, respectively. He and Tian (2000) reported that many other studies have estimated own price elasticities of demand for pork and poultry in China were within the above range. That is, own price demand elasticity for pork fell between -0.04 and -1.59. And the own price elasticity for poultry fell between -0.005 and -1.28. Zhuang and Abott (2005) estimated demand elasticities for pork (-0.27)and poultry meat (-0.44). Liu et al (2009) conducted a survey and separate consumers in two groups – urban and rural, and employed AIDS model to estimate. This is a most recent study of China's meat consumption pattern, a set of the numerical values of the demand and income elasticities from that paper will be used in this study. However, Liu et al(2009) only reported the lower triangle of the demand elasticities, which is the motivation for us to apply the general restriction of symmetry for Marshallian elasticities. By making the use of equation (4.3), we could obtain all values of demand price elasticities in the full 5×5 matrix.

$$\eta_{ij} = \frac{R_j}{R_i}\eta_{ji} + R_j(A_j - A_i) \tag{4.3}$$

where R_i is the budget share of good i, and A_i is the expenditure elasticity for good i.

All of the demand price elasticities and Income elasticities are listed in table 4.4.

Table 4.4: Marshallian Demand Price Elasticities and Income Elasticities

Urban	Pork	Poultry	Beef	Mutton	AP	*Income*
Pork	-1.16^a	0.01^b	0.30^b	0.12^b	0.98^b	0.63^b
Poultry	-0.10^a	-1.05^a	0.02^b	0.61^b	1.24^b	0.98^a
Beef	0.43^a	-0.07^a	-1.64^a	0.73^b	2.97^b	1.45^b
Mutton	0.14^a	1.13^a	1.03^a	-1.89^a	3.30^b	1.42^a
AP	1.20^a	1.02^a	1.83^a	1.45^a	-1.16^a	1.27^a
Rural	Pork	Poultry	Beef	Mutton	AP	*Income*
Pork	-0.94^a	-0.01^b	0.02^b	0.03^b	-0.29^b	0.93^b
Poultry	0.04^a	-2.11^a	-0.03^b	0.09^b	0.64^b	0.80^b
Beef	0.13^a	-0.17^a	-2.19^a	0.42^b	2.51^b	1.15^b
Mutton	0.06^a	0.17^a	0.30^a	-2.61^a	0.98^b	1.18^a
AP	-1.04^a	0.68^a	0.79^a	0.44^a	-1.45^a	1.04^a

Source: [a] Liu et.al 2009; [b] author's calculation

4.3 Farm Supply Elasticities: Vertical Structure of Production

Above we have considered a multi-products domestic meat market. But in reality, production of meat for consumers involves various stages that separate the industry into different sectors. Here we take the most consumed meat in China — pork — as an example, to analyse the vertical structure of meat production and marketing. A typical pork production system can be stylized as follows. The sows are bred and produced in the farms or households; they are then sold as finished live hogs to go to slaughter house; they are slaughtered and processed in the abattoirs and then sold as pig meat to domestic retailers. Thus, we set the structural model as follows:

$$Q_1^S = D(P_1^S) \qquad \text{(Demand for Hogs at Farm Level)} \tag{4.4}$$

$$Q_1^S = f(Q_1^F, Q_1^N) \qquad \text{(Hog Production Function)} \tag{4.5}$$

$$P_1^H = MP_1^H P_1^S \qquad \text{(Demand for Feed Inputs)} \tag{4.6}$$

$$P_1^G = MP_1^G P_1^S \qquad \text{(Demand for Non-feed Inputs)} \tag{4.7}$$

$$P_1^H = g(Q_1^F) \qquad \text{(Inverse Supply of Feed Inputs)} \tag{4.8}$$

$$P_1^G = h(Q_1^N) \qquad \text{(Inverse Supply of Non-feed Inputs)} \tag{4.9}$$

which is the Muth-type Model with Gardner's "primal" specification (Gardner, 1975). And following assumptions are set:

a) Perfect competition in all market (firms are price taker);

b) Profit maximization at all levels, i. e. input and output markets;

c) Hog production function exhibits CRTS.

Then by dropping farm-level demand for hogs, since P^S is treated exogenous temporarily, we put the model into EDM form:

$$EQ_1^S = S_1^F EF_1 + S_1^N EN_1 \qquad \text{(Production of Hogs)} \tag{4.10}$$

$$EP_1^F = -\frac{S_1^N}{\sigma} EQ_1^F + \frac{S_1^N}{\sigma} EQ_1^N + EP_1^S \qquad \text{(Demand for Feed Inputs)} \tag{4.11}$$

$$EP_1^N = \frac{S_1^F}{\sigma} EQ_1^F - \frac{S_1^F}{\sigma} EQ_1^N + EP_1^S \qquad \text{(Demand for Non-feed Inputs)} \tag{4.12}$$

$$EP_1^F = \frac{1}{\varepsilon_1^F} EQ_1^F \qquad \text{(Supply of Feed Inputs)} \tag{4.13}$$

$$EP_1^N = \frac{1}{\varepsilon_1^N} EQ_1^N \qquad \text{(Supply of Non-feed Inputs)} \tag{4.14}$$

where the operator $E(X) = \dfrac{dX}{X} = d\log(X)$ indicates relative change in variable X, for prices (P) and quantities (Q), superscripts F denotes for feed inputs while N denotes for non-feeding inputs, and the undefined variables and parameters are σ = the elasticity of substitution between feed and non-feed inputs, $S^F = \dfrac{P^F Q^F}{P^S Q^S}$ = cost share of feed inputs, $S^N = \dfrac{P^N Q^N}{P^S Q^S}$ = cost share of non-feed inputs. The farm supply curve is obtained by dropping farm-level demand for hogs since P^S is treated exogenous temporarily, and we solve the remaining equations simultaneously for EQ_1^S in terms of EP_1^S to yield:

$$EQ_1^S = \frac{(\sigma e + \varepsilon_1^F \varepsilon_1^N)}{D} EP_1^S \qquad \text{(Derived Supply Curve)}$$

where $e = (S_1^F \varepsilon_1^F + S_1^N \varepsilon_1^N)$ = *the overall factor supply elasticity*, and $D = (\sigma + S_1^F \varepsilon_1^N + S_1^N \varepsilon_1^F)$. Since e and D are positive for normal parameter values, the coefficient of EP_1^S for EQ_1^S is positive, which implies the farm supply curve is upward sloping. And the overall supply elasticity is stated explicitly as:

$$\varepsilon_1 = \frac{(\sigma e + \varepsilon_1^F \varepsilon_1^N)}{D} = \frac{\sigma(S_1^F \varepsilon_1^F + S_1^N \varepsilon_1^N) + \varepsilon_1^F \varepsilon_1^N)}{(\sigma + S_1^F \varepsilon_1^N + S_1^N \varepsilon_1^F)} \qquad (4.15)$$

Zhuang and Abbott (2005) estimated the supply elasticities for wheat(0.311), rice(0.273), and corn (0.230). For simplicity, we set the feed inputs supply elasticity to $\varepsilon^G = 0.3$. And the non-feed inputs supply elasticity is set to $\varepsilon^H = 1.0$. Feed inputs cost share is set to $S_1^H = 0.4$, which implies the non-feed inputs cost share is $S_1^G = 0.6$, due to the pork production cost information.

To quantify the supply elasticity, we "simulated" the elasticity expressions for a plausible range of parameter values as indicated in table 4.5. The simulation indicates the supply elasticity for pork, ε_1 has a relevant range between 0.48 and 0.56, with a mean value of 0.52, which implies that if the pork price increases by 1%, the pork supply will increase by 0.52%.

The poultry, beef and mutton supply elasticities are obtained similarly. For poultry, which depends mostly on the feed cost, we set the feed (grain) cost share is $S_2^G = 1$, so that

Table 4.5: Pork Supply Elasticity for Alternative Values of the Factor Substitution (σ)

σ	Supply Elasticity
0.5	0.48
1	0.51
2	0.54
4	0.56
Mean	**0.52**

the supply elasticity for pork is:

$$\varepsilon_2 = \frac{\sigma(S_2^H \varepsilon_2^H + S_2^G \varepsilon_2^G) + \varepsilon_2^H \varepsilon_2^G}{\varepsilon + S_2^H \varepsilon_2^G + S_2^G \varepsilon_2^H} = 0.30$$

For beef and mutton, since in China, most of the herds are grazed in the prairies with free grass, we set the feed (grain) cost share to zero, so that the supply elasticities for beef and mutton are $\varepsilon_3 = \varepsilon_4 = 1.0$.

For aquatic products, things are more complicated. The supply of aquatic products could be farmed, as well as could be wild-caught. It could be harvested from fresh water, as well as from the sea. Similar with the pork supply, we calculate the supply elasticity for aquatic product with the expression:

$$\varepsilon_5 = \frac{\sigma(S_5^F \varepsilon_5^F + S_5^C \varepsilon_5^C) + \varepsilon_5^F \varepsilon_5^C}{\sigma + S_5^F \varepsilon_5^C + S_5^C \varepsilon_5^F} \tag{4.16}$$

where S_5^F is the cost share of feeding, which is set to 0.7, due to the production data of China's fishery, so that the cost share of catching, $S_5^C = 0.3$. The feeding supply elasticity is still set to $\varepsilon_5^F = 0.3$, and the catching-supply elasticity is set to $\varepsilon_5^C = 1.0$. By simulation, we get the supply elasticity of aquatic product with the value of 0.74.

However, to assess the sensitivity of results to the supply elasticities, and to provide an estimate of the "short-run" which implies in one year or less, responses to the exogenous variables, we ran an additional simulation with $\varepsilon_1' = \varepsilon_2' = \varepsilon_3' = \varepsilon_4' = \varepsilon_5' = 0$.

Table 4.6: AP Supply Elasticity for Alternative Values of the Factor Substitution (σ)

σ	Supply Elasticity
0.5	0.69
1	0.72
2	0.75
4	0.77
Mean	**0.74**

4.4 Price Transmission Elasticity

The farm-wholesale price transmission elasticity for urban is calculated by the theoretical price transmission equation (Gardner, 1975):

$$\omega_i = \frac{\sigma_i + S_i^F e_b + (1 - S_i^F)\varepsilon_i}{(\sigma_i + e_b)} \tag{4.17}$$

where σ_i is the elasticity of substitution between the farm-based input and the bundle of marketing services, e_b is the elasticity of supply of marketing services, S_i^F is the cost share of the farm-based input, and ε_i is the previously defined supply elasticity. The equation assumes competitive market clearing, constant returns to scale, and isolated shifts in retail demand. [1] (Kinnucan and Forker, 1986)

The cost-share parameter values are obtained by calculating with the market and farm-gate price data, collected by NBS (National Bureau of Statistics, China). Assume fixed-proportions, the elasticity of substitution between the farm-based input and the bundle of marketing services σ_i is set to zero. And the elasticity of supply of marketing services, e_b, is set to infinity, since preliminary experimentation indicated results were not sensitive to alternative values. Then the price transmission equation reduces to $\omega_i = S_i^F$. Since urban consumers demand more value-added than the rural consumers do, intuitively, the urban price transmission elasticities are less than the rural ones ($\omega_i^U < \omega_i^R$). Therefore, to

[1] For isolated shifts in farm supply, $\omega_i = \frac{(1-S_i^F)(\sigma_i+e_b)}{e_b+(1-S_i^F)\sigma_i - S_i^F\eta_i}$, where η_i is the retail demand elasticity for the commodity. (Kinnucan & Forker, 1986, P.290, Table 4, footnote c)

Table 4.7: Urban & Rural Price Transmission Elasticities

	Pork	Poultry	Beef	Mutton	AP
Farmers' Share of Retail Price	59%	80%	38%	40%	58%
Urban Price Transmission Elasticity	0.54	0.75	0.33	0.35	0.53
Rural Price Transmission Elasticity	0.64	0.85	0.43	0.45	0.63

Source: NBS data and author's calculation

distinguish the urban and rural market, we simply set $\omega_i^U = (S_i^F - 5\%)$ and $\omega_i^R = (S_i^F + 5\%)$ under the assumption that urban consumers demand is 10% more sensitive than rural. And we obtained values of price transmission elasticities for urban and rural in table 4.7.

Table 4.8: Definitions and Values of All Parameters

Parameter	**Definition**	**Value**				
		Pork	Poultry	Beef	Mutton	AP
Urban						
η_{1j}^U	Demand Elasticity W.R.T. Pork	-1.16	0.01	0.30	0.12	0.98
η_{2j}^U	Demand Elasticity W.R.T. Poultry	-0.10	-1.05	0.02	0.61	1.24
η_{3j}^U	Demand Elasticity W.R.T. Beef	0.43	-0.07	-1.64	0.73	2.97
η_{4j}^U	Demand Elasticity W.R.T. Mutton	0.14	1.13	1.03	-1.89	3.30
η_{5j}^U	Demand Elasticity W.R.T. AP	1.20	1.02	1.83	1.45	-1.16
δ_i^U	Income Elasticity	0.63	0.98	1.45	1.42	1.27
k_i^U	Consumption Share	0.50	0.63	0.65	0.57	0.66
ω_i^U	Price Transmission Elasticity	0.54	0.75	0.33	0.35	0.53
Rural						
η_{1j}^R	Demand Elasticity W.R.T. Pork	-0.94	-0.01	0.02	0.03	-0.29
η_{2j}^R	Demand Elasticity W.R.T. Poultry	0.04	-2.11	-0.03	0.09	0.64
η_{3j}^R	Demand Elasticity W.R.T. Beef	0.13	-0.17	-2.19	0.42	2.51
η_{4j}^R	Demand Elasticity W.R.T. Mutton	0.06	0.17	0.30	-2.61	0.98
η_{5j}^R	Demand Elasticity W.R.T. AP	-1.04	0.68	0.79	0.44	-1.45
δ_i^R	Income Elasticity	0.93	0.80	1.15	1.18	1.04
k_i^R	Consumption Share	0.50	0.37	0.35	0.43	0.34
ω_i^R	Price Transmission Elasticity	0.64	0.85	0.43	0.45	0.63
Farm						
ε_i	Supply Elasticity (Long-run)	0.52	0.30	1.00	1.00	0.74
ε_i'	Supply Elasticity (Short-run)	0	0	0	0	0

In sum, definitions and values of all parameters are shown in table 4.8 (See table 4.8).

Chapter 5

Simulation Results

5.1 Income Effects

We focus first on income effects. Table 5.1 presents all the prices and quantities response to income growth. The results are neither similar to those found in the literature, nor conformed to our conjecture.

In the long-run period, the effects of income growth on most of the prices and quantities are too big to believe, e.g. the results suggest that some of the meat prices would rise more than 100% as income grows by 10%, and finally cause the supplies (which is equal to the total quantities of consumption) increased up to 400%. As for short-run, however, the results shows income effects on all meat's prices are negative, except for pork. It cannot be simply explained by consumers diverted their preferences wholly on pork, therefore decreases the equilibrium prices of other meat.

Several readers of an earlier draft of this thesis suggested the counter-intuitive negative result might inhere in the cross-commodity substitution effects and supply response. Perhaps the negative total income elasticity values come from a two-run procedure: at first, the growth of income causes all the prices and quantities to rise; and then in the second-run, some complementary effects between the commodities drag some of the values back to negative ones. Indeed, if we look back at the demand price-elasticities matrix (**N**) in the parameterization part, we find several negative cross-price elasticities, which imply that these two goods are complements. And some of the negative values are large numbers. In response, we construct an N matrix by replacing all negative cross-price elasticities with zeros, and repeat the simulation. Under this scenario, we get the results in table 5.2.

Table 5.1: Income Effects, with Original Cross-price Elasticities

		Upward-sloping Supply	Fixed Supply ($\varepsilon_i' = 0$)
Supply Quantities	Pork	2.71	0
	Poultry	3.10	0
	Beef	22.39	0
$(\frac{EQ_i^S}{EY})$	Mutton	20.25	0
	AP	14.80	0
Urban Quantities	Pork	10.92	-0.96
	Poultry	10.15	-0.42
	Beef	26.63	-0.33
$(\frac{EQ_i^U}{EY})$	Mutton	39.77	-1.63
	AP	24.04	-0.42
Rural Quantities	Pork	-5.50	0.96
	Poultry	-8.92	0.71
	Beef	14.50	0.61
$(\frac{EQ_i^U}{EY})$	Mutton	-5.63	2.16
	AP	-3.12	0.82
Supply Prices	Pork	5.21	0.42
	Poultry	10.32	-0.39
	Beef	22.39	-2.83
$(\frac{EP_i^S}{EY})$	Mutton	20.25	-2.14
	AP	20.01	-1.83
Urban Prices	Pork	2.81	0.23
	Poultry	7.74	-0.29
	Beef	7.39	-0.94
$(\frac{EP_i^U}{EY})$	Mutton	7.09	-0.75
	AP	10.60	-0.97
Rural Prices	Pork	3.34	0.27
	Poultry	8.77	-0.33
	Beef	9.63	-1.22
$(\frac{EP_i^R}{EY})$	Mutton	9.11	-0.96
	AP	12.60	-1.15

According to table 5.2, after deleting the complementary effects, the large numbers are getting dramatically larger, and the negative values are still there. No one is going to believe in this result, and we doubt whether the data collected from Liu et.al (2009) is correct or problematic. A review of the original demand price elasticity matrix (**N** matrix) in table 4.4 shows that although we imposed symmetry, the estimates are still not conformed with

Table 5.2: Income Effects, Deleting Negative Cross-price Elasticities

		Upward-sloping Supply	Fixed Supply ($\varepsilon_i' = 0$)
Supply Quantities	Pork	20.57	0
	Poultry	18.81	0
$(\frac{EQ_i^S}{EY})$	Beef	140.54	0
	Mutton	123.55	0
	AP	93.51	0
Urban Quantities	Pork	61.20	-0.78
	Poultry	61.75	-0.37
$(\frac{EQ_i^U}{EY})$	Beef	164.84	-0.33
	Mutton	244.63	-1.59
	AP	144.75	-0.56
Rural Quantities	Pork	-20.07	0.78
	Poultry	-54.30	0.64
$(\frac{EQ_i^U}{EY})$	Beef	95.42	0.60
	Mutton	-36.94	2.11
	AP	-5.95	1.09
Supply Prices	Pork	39.55	0.17
	Poultry	62.70	-0.36
$(\frac{EP_i^S}{EY})$	Beef	140.54	-2.83
	Mutton	123.55	-2.08
	AP	126.36	-1.79
Urban Prices	Pork	21.36	0.09
	Poultry	47.02	-0.27
$(\frac{EP_i^U}{EY})$	Beef	46.38	-0.94
	Mutton	43.24	-0.73
	AP	66.97	-0.95
Rural Prices	Pork	25.31	0.11
	Poultry	53.29	-0.31
$(\frac{EP_i^R}{EY})$	Beef	60.43	-1.22
	Mutton	55.60	-0.94
	AP	79.61	-1.13

other general restrictions, neither Cournot (Adding-up) nor the homogeneity condition. Take the urban demand price elasticities for example, by multiplying the first column with the expenditure elasticities, respectively, the Cournot condition value for pork is -0.05, which should be -0.33 (the negative value of its budget share). The summation of the last line's original values would get surprising 5.61, however, it should be zero according to homogeneity.

Table 5.3: Violation of General Restrictions

Marshallian Price Elasticities (Urban)					Budget	Expenditure	Homogeneity
Pork	Poultry	Beef	Mutton	Fish	Shares	Elasticities	Condition:
-1.16					0.33	**0.63**	
-0.10	-1.05				0.20	0.98	
0.43	-1.64				0.14	1.45	
0.14	-1.89				0.10	1.42	
1.20	1.02	1.83	1.45	-1.16	0.23	1.27	**5.61**
-0.05	(Cournot Condition)						

Given the deviation from intuition of all the results exhibited above, a skeptical reader might wonder whether our simulation process is correct. In order to prove this, we construct a new **N** matrix by setting all the cross-price elasticities as zero, and do an experiment by using the same simulation process. Partial versus total income elasticities are given in table 5.4.

Results look elegant finally, and the values are what we have expected suggested by the comparative statics chapter, the total elasticities are smaller than partial elasticities ($\delta^T = \dfrac{\delta\varepsilon}{\varepsilon + k^U\eta^U\omega^U + k^R\eta^R\omega^R}$). In the long-run period, when the supplies are upward-sloping, the total elasticities to income are uniformly less than the partial ones, and only beef is income elastic in the urban market. As in the short-run period, total consumption cannot vary while the supplies are fixed, the rural buyers consume more pork, while the urban buyers will consume more other meat as income grows. Obviously when the rural/urban buyers increase their consumption on a meat product. A plausible explanation is that as income grows, urban people tend to buy higher quality and more expensive meat rather than their traditional staple meat — pork.

Meat prices have increased significantly in recent years and it has become a big problem in China. From this result we can see part of the reason. According to the results in table 5.5, prices of all kinds of meat at all market will increase as income grows, if we do not take cross-effects into account, which shows the increasing income definitely brings more benefit for Chinese people, such as consuming more meat. However, the effects of income growth

Table 5.4: Partial versus Total Income Elasticities, no Cross-commodity Effects

		Partial Elasticity	Total Elasticity ($\frac{EQ_i}{EY}$)	
		(δ)	Long-run	Short-run
SUPPLY	Pork	0.78	0.36	0
	Poultry	0.87	0.19	0
	Beef	1.26	0.80	0
($\frac{EQ_i^S}{EY}$)	Mutton	1.28	0.70	0
	AP	1.12	0.61	0
URBAN	Pork	0.63	0.20	-0.17
	Poultry	0.98	0.49	0.36
	Beef	1.45	1.02	0.38
($\frac{EQ_i^U}{EY}$)	Mutton	1.42	0.96	0.43
	AP	1.27	0.77	0.25
RURAL	Pork	0.93	0.52	0.17
	Poultry	0.80	-0.32	-0.61
	Beef	1.15	0.40	-0.71
($\frac{EQ_i^R}{EY}$)	Mutton	1.18	0.36	-0.57
	AP	1.04	0.29	-0.48

on meat prices are not very significant, it cannot tell us the whole story for the frequent fluctuation of meat prices in China.

Meat prices are more sensitive to income in the short-run period than they are in the long-run, which also indicates that China should ensure increasing supply of meat, to avoid frequent fluctuation of meat prices. Luckily, the supply prices' responses to income growth are elastic. Intuitively, there are two reasons for that, one is the farm prices are often less than retail prices, therefore the percentage changes on farm prices are larger; and the other intuition is that people tend to buy more meat as income grows, the increase demand and fixed supply would absolutely cause an obvious rise in supply prices. As in the long-run, the supply will increase as a feedback of the rising price and even into the situation of surfeit supply, this in turn would decrease the demand price.

Table 5.5: Income Effects on Meat Prices, no Cross-commodity Effects

		Upward-sloping Supply	Fixed Supply ($\varepsilon_i' = 0$)
SUPPLY	Pork	0.69	1.27
	Poultry	0.63	0.79
	Beef	0.80	1.97
$(\frac{EP_i^S}{EY})$	Mutton	0.70	1.49
	AP	0.82	1.66
URBAN	Pork	0.37	0.69
	Poultry	0.47	0.60
	Beef	0.26	0.65
$(\frac{EP_i^U}{EY})$	Mutton	0.24	0.52
	AP	0.43	0.88
RURAL	Pork	0.44	0.81
	Poultry	0.53	0.67
	Beef	0.34	0.85
$(\frac{EP_i^R}{EY})$	Mutton	0.31	0.67
	AP	0.52	1.05

5.2 The Importance of Cross-commodity Effect

As we have shown above, the original elasticity values taken from Liu et al.(2009) are problematic, in that they violate the general restrictions of demand theory. A final conjecture is that there might be something inherent to the economical procedure that produces counter-intuitive results from how the cross-commodity elasticities vary. In order to investigate this possibility, let us do an experiment with intentionally absurd demand price-elasticity matrices (**N** matrix).

Specifically, we omit the criteria that one could use to construct an **N** matrix, simply keep the diagonal values of the **N** matrix (the own-price elasticities) and replace the values of the rest with several groups of non-zero cross-price elasticities we 'produced', then do simulations under these different "number tricks" scenarios.

The results in able 5.6 and table 5.7 convince us that the effects of exogenous variables (in this study, it is the income) are very sensitive to the values of cross-commodity elasticities, and the counter-intuitive results (e.g. negative total income elasticities) are not merely

Table 5.6: Different Cross-commodity Elasticities Simulation Results 1 ($\frac{EQ}{EY}$)

SUPPLY ($\frac{EQ_i^S}{EY}$)	**URBAN** ($\frac{EQ_i^U}{EY}$)		**RURAL** ($\frac{EQ_i^R}{EY}$)	
Long-run	Long-run	Short-run	Long-run	Short-run
Scenario 1: set all cross-price elasticities as 0.2				
0.60	0.33	-0.58	0.56	0.28
0.34	0.49	0.36	0.26	-0.44
1.12	1.19	-0.11	1.29	0.50
1.03	1.08	-0.12	1.19	0.39
0.82	1.00	0.41	0.71	-0.56
Scenario 2: set all cross-price elasticities as 0.5				
1.89	2.00	-0.33	1.47	0.03
1.17	1.17	-0.02	1.34	0.22
3.19	3.47	0.03	2.98	-0.24
2.95	3.22	0.01	2.83	-0.23
2.41	3.04	-0.46	1.41	1.11
Scenario 3: set all cross-price elasticities as 1.0				
-1.16	-1.70	-0.29	-0.92	0.01
-0.58	-1.10	-0.23	0.48	0.58
-1.59	-1.97	-0.12	-0.56	0.53
-1.43	-1.95	-0.19	-0.52	0.50
-1.21	-1.86	-0.28	0.29	0.77
Scenario 4: set all cross-price elasticities as 0.8				
-2.34	-3.28	-0.35	-1.69	0.05
-1.36	-1.56	-0.07	-0.82	0.30
-3.50	-4.06	-0.07	-2.16	0.43
-3.21	-3.88	-0.12	-2.08	0.40
-2.68	-3.72	-0.26	-0.43	0.74
Scenario 5: set all cross-price elasticities as 0.6				
3.52	3.71	-0.19	3.03	0.11
1.85	3.11	-0.43	-0.11	0.91
5.52	6.33	-0.12	4.31	0.53
5.03	6.00	-0.21	3.97	0.52
4.13	5.67	-0.49	1.38	1.18
Scenario 6: set all cross-price elasticities as 0.7				
-51.28	-59.69	-0.24	-43.17	0.06
-26.59	-46.10	-0.34	6.80	0.75
-77.39	-90.58	-0.12	-52.60	0.53
-70.38	-86.74	-0.20	-48.44	0.51
-58.20	-82.24	-0.39	-11.28	0.98
Scenario 7: set all cross-price elasticities as 0.65				
7.66	8.50	-0.22	6.51	0.08
4.00	6.83	-0.37	-0.63	0.82
11.78	13.64	-0.12	8.61	0.53
10.72	13.00	-0.21	7.93	0.52
8.83	12.30	-0.43	2.33	1.06

Table 5.7: Different Cross-commodity Elasticities Simulation Results 2 ($\frac{EP}{EY}$)

SUPPLY ($\frac{EP_i^S}{EY}$)		**URBAN** ($\frac{EP_i^U}{EY}$)		**RURAL** ($\frac{EP_i^R}{EY}$)	
Long-run	Short-run	Long-run	Short-run	Long-run	Short-run
Scenario 1: set all cross-price elasticities as 0.2					
1.15	4.01	0.70	2.44	0.39	1.36
1.13	2.71	0.91	2.18	0.47	1.14
1.12	4.51	0.50	1.99	0.22	0.90
1.03	3.79	0.47	1.74	0.22	0.79
1.11	3.61	0.67	2.19	0.57	1.84
Scenario 2: set all cross-price elasticities as 0.5					
3.63	-3.78	2.21	-2.30	1.23	-1.28
3.89	-3.02	3.13	-2.44	1.63	-1.27
3.19	-3.55	1.41	-1.57	0.64	-0.71
2.95	-3.06	1.36	-1.41	0.62	-0.64
3.25	-3.04	1.97	-1.84	1.66	-1.55
Scenario 3: set all cross-price elasticities as 1.0					
-2.23	-1.23	-1.36	-0.75	-0.76	-0.42
-1.93	-0.80	-1.56	-0.65	-0.81	-0.34
-1.59	-0.82	-0.70	-0.36	-0.32	-0.16
-1.43	-0.69	-0.66	-0.32	-0.30	-0.15
-1.64	-0.76	-0.99	-0.46	-0.83	-0.39
Scenario 4: set all cross-price elasticities as 0.8					
-4.49	-1.51	-2.74	-0.92	-1.53	-0.51
-4.52	-1.16	-3.64	-0.94	-1.90	-0.49
-3.50	-1.17	-1.55	-0.52	-0.70	-0.23
-3.21	-1.00	-1.48	-0.46	-0.67	-0.21
-3.62	-1.06	-2.19	-0.64	-1.84	-0.54
Scenario 5: set all cross-price elasticities as 0.6					
6.77	-2.94	4.13	-1.79	2.30	-1.00
6.18	-1.94	4.98	-1.56	2.59	-0.81
5.52	-2.43	2.44	-1.08	1.10	-0.49
5.03	-2.05	2.32	-0.94	1.06	-0.43
5.58	-2.09	3.38	-1.26	2.85	-1.06
Scenario 6: set all cross-price elasticities as 0.7					
-98.61	-2.15	-60.13	-1.31	-33.53	-0.73
-88.63	-1.41	-71.48	-1.14	-37.23	-0.59
-77.39	-1.67	-34.24	-0.74	-15.48	-0.33
-70.38	-1.41	-32.43	-0.65	-14.78	-0.30
-78.64	-1.46	-47.66	-0.89	-40.11	-0.75
Scenario 7: set all cross-price elasticities as 0.65					
14.73	-2.48	8.98	-1.51	5.01	-0.84
13.33	-1.63	10.75	-1.31	5.60	-0.68
11.78	-1.99	5.21	-0.88	2.36	-0.40
10.72	-1.67	4.94	-0.77	2.25	-0.35
11.94	-1.72	7.23	-1.04	6.09	-0.88

artifacts of the data simulation procedure. We see where the negative total income elasticities come from: when the cross-effects are small, say, 0.2, we get the positive results close to the ones we obtained when we set all cross-effects as zero. Then, for the long-run period, as we increase the cross-effects value (from 0.5, 0.6 to 0.65), the values of the positive results increase as well. However, if we set the cross-price elasticities to 1.0, we got negative results. And as we make the cross-effects values go down, the absolute value of the negative results increase rapidly. When cross-effects are set at 0.7, we obtain unrealistically large negative numbers. It seems that there is a turning point when cross-elasticities are between 0.65 and 0.7, and at the turning point, the total income effects suddenly go to negative infinity from positive infinity. Mathematical intuitively, the relative changes of endogenous variables (prices and quantities) with respect to exogenous variable (e. g. income) can be represented as a function of the cross-commodity elasticities, in the form of, or approximately relating to a hyperbola curve. And the intersection point of its symmetry axis is at the interval between 0.65 and 0.7. In fact, if we look back the matrix model, we could find the coefficient of the income is an inverse matrix, which is of power degree (-1). And for short-run, there is also a turn-point, which is at the interval between 0.2 and 0.5.

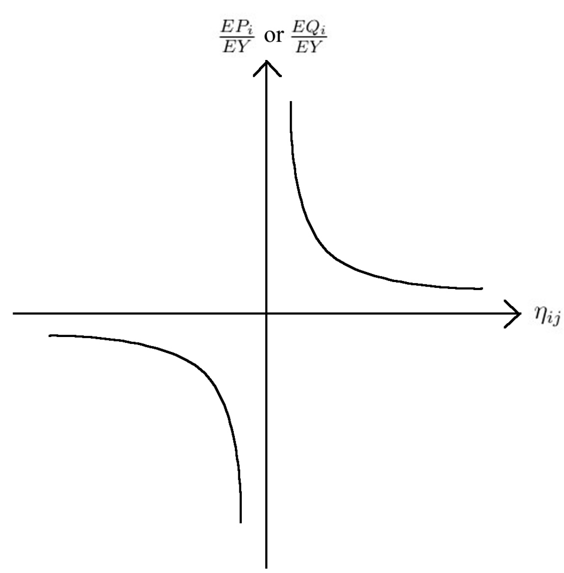


Figure 5.1: Hyperbola Curve

This could mathematically make sense, and as in chapter 2, equation (2.35) has explicitly showed the matrix inversion mechanic in the simplest way — the two commodity market, we may encounter "quasi-singularity" problem when $\prod(\varepsilon_i - \eta_{ii})$ and $\prod_{i \neq j} \eta_{ij}$ are close enough, the inverse matrix tends to be singular, and dramatically large numbers are plausible. For 5 commodities case, things are much more complicated, even the process for inverting a 5×5 matrix is difficult, but the basic ideas should be the same. And the economical meaning of this process needs to be investigated more carefully.

5.3 Pork Price Subsidy Effects

Results in table 5.8 show how prices and quantities of pork are influenced under the subsidy circumstance in the pork market without considering other kinds of meat, where we set all cross-price elasticities for pork as zero.

In long-run period, the pork price subsidy would increase the supply price of pork and meanwhile reduce the demand its prices in both urban and rural market, which means that the subsidy will benefit both the pork suppliers and the consumers. In particular, assume there is a 10% increase in the subsidy, the supply price of pork would increase by 9.3%, while the demand price would decrease by 5.0% in urban market and by 4.0% in rural market. The results also show that the subsidy would raise the pork's equilibrium quantity in both urban and rural demand market. Similarly, a 10% increase in the subsidy will cause the total supply of pork increased by 4.8%, also raise the pork consumption by 5.8% in urban and by 3.8% in rural.

Table 5.8: Pork Subsidy Effects, With Nil Cross-commodity Effects

	$\frac{EP_1^S}{EZ}$	$\frac{EP_1^U}{EZ}$	$\frac{EP_1^R}{EZ}$	$\frac{EQ_1^S}{EZ}$	$\frac{EQ_1^U}{EZ}$	$\frac{EQ_1^R}{EZ}$
Long-run	0.93	-0.50	-0.40	0.48	0.58	0.38
Short-run	1.71	-0.08	0.09	0	0.09	-0.09

As in the short-run period, where we set the pork supply fixed, the results suggest that the subsidy would have different effects on the urban and rural consumers' welfare. The subsidy would definitely benefit the pork producers by increasing the supply price, however, the demand price also rises in the rural market, which implies that the urban consumers suffer loss, so that the suppliers and urban consumers could enjoy more benefit besides the subsidy. Specifically, a 10% increase in this subsidy would raise the supply price of pork by 17.1%, and raise the rural demand price by 0.8%, but reduce the rural demand price of pork by 0.9%. The price changes in turn influenced the equilibrium quantities in each demand market, fixed supply is diverted from urban to rural market (See Fig 5.2). A fall in urban pork price causes the urban supply to increase, and a rise in rural pork price decreases the rural supply. Still assume a 10% increase in the pork price subsidy, the urban pork consumption would be raised by 0.9%, while the urban pork consumption would be reduced by 0.9%. The producers gain most of the benefit from the subsidy. And the subsidy would also benefit the urban consumers in the way of both decreasing the price and increase the consumption. The results also illustrates the principle that the less elastic side of the market bears the greater incidence of the subsidy.

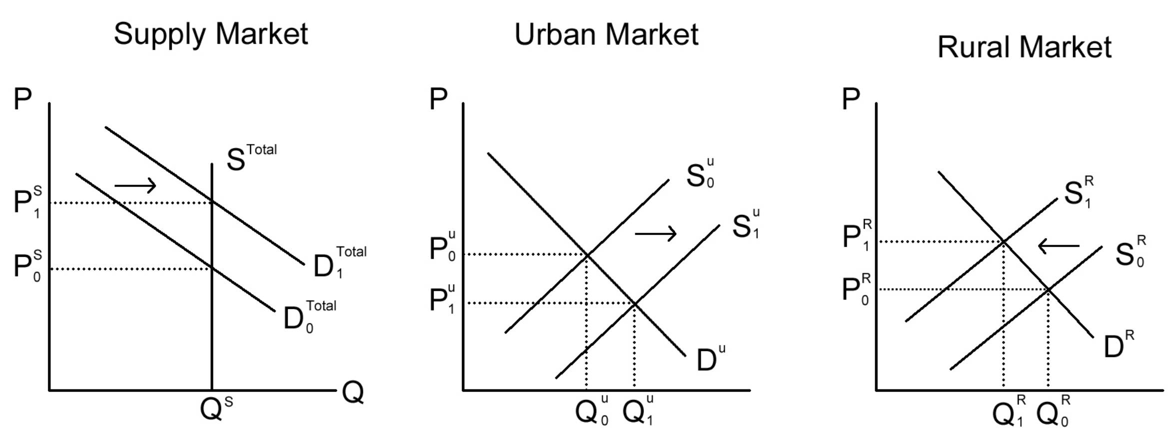


Figure 5.2: Fixed Supply Diverted from Urban to Rural under Subsidy

Table 5.9: Pork Subsidy Effects, with Original Cross-price Elasticities

	Price Effects		**Quantity Effects**	
	Long-run	Short-run	Long-run	Short-run
Supply Market	$(\frac{EP_i^S}{EZ})$		$(\frac{EQ_i^S}{EZ})$	
Pork	0.43	1.73	0.22	0
Poultry	-1.05	0.04	-0.32	0
Beef	-2.48	0.10	-2.48	0
Mutton	-2.17	0.10	-2.17	0
AP	-2.22	0.04	-1.64	0
Urban Market	$(\frac{EP_i^U}{EZ})$		$(\frac{EQ_i^U}{EZ})$	
Pork	-0.77	-0.06	-0.61	0.11
Poultry	-0.79	0.03	-1.03	0.02
Beef	-0.82	0.03	-2.98	0.01
Mutton	-0.76	0.04	-4.29	0.05
AP	-1.18	0.02	-2.96	0.04
Rural Market	$(\frac{EP_i^R}{EZ})$		$(\frac{EQ_i^R}{EZ})$	
Pork	-0.73	0.11	1.05	-0.11
Poultry	-0.89	0.03	0.90	-0.04
Beef	-1.06	0.04	-1.54	-0.01
Mutton	-0.97	0.05	0.65	-0.07
AP	-1.40	0.02	0.91	-0.07

The model for subsidy effect was forward simulated on the whole five-commodity meat market which includes all cross-price elasticities, the results in table 5.9 show that the effects of the change in the subsidy on pork have not varied much from the results with nil cross-commodity effects, since the subsidy is imposed directly on the pork price. Moreover, the subsidy effects on other meat cannot be neglected. In the long-run period, as we expected, the pork subsidy reduces the prices of all other meat, due to pork's substitution effects, and this also drags their equilibrium quantities down. As for shot-run period, however, the effects are less clear, for other meat shows complementary effects for pork, although slightly, their prices increase. And another interesting point is that the fixed supplies are also diverted from rural to urban market.

Chapter 6

Conclusion

In this thesis, we set up an EDM model of five related commodities in two parallel demand markets, to show the effects of income growth and a pork price subsidy on China's meat market. The most difficult methodological problems in this study are the results of cross–commodity effects. In the process of simulation, we arrived at some counter-intuitive results, we find that the total income elasticities are negative if we use the demand elasticity values from Liu et al.(2009). After investigation into the demand elasticities more carefully, we found that they violate theoretical restrictions of homogeneity and adding-up.

What is likely to be the most significant factor that causes the strange negative total income elasticity values? Theory does not provide firm answers, so we experiment with several alternatives. We first ruled out the possibility that the complementary cross-effects push some of the income effect negative. However, we find it extremely encouraging, that the values of cross-commodity elasticities influence the effects of exogenous variables in another way, if we re-simulate the model with different intentionally-set cross-commodity elasticity values. There might be a function to show the relationship between the result variables (the relative changes in the market with respect to exogenous variables, e. g. $\frac{EP}{EY}$ or $\frac{EQ}{EY}$) and the cross-commodity elasticities in the form of, or at least approximately relating to a hyperbola curve (temporarily assume the cross-commodity elasticity is endogenous, and other variables are constant). Moreover, we showed the relation in the simplest two commodity EDM model and proved the possibility of negative results. Mathematically, it comes from the mechanics of matrix inversion, yet its economic meaning needs to be investigated more carefully.

The effects of exogenous variables are sensitive to the values of cross-commodity relations. The issue of cross-commodity substitution is particularly relevant in the analysis of meat markets, as meats are expensive and consumers will react to changes in relative prices by substituting relatively less expensive meat products for the relatively more costly items. If we set all cross-effects to zeros, we would get the results that are expected. Income growth increases all meat prices and total demand. It seems that prices are more sensitive to income in the short-run than that in the long-run. In the long-run, the supply will increase as a feedback of the rising price and even into the situation of surplus supply, this in turn would decrease the demand price.

A subsidy imposed on pork price by the Chinese government in case of too high pork price helps stabilize the pork supply. In the long-run, it seems that the subsidy would raise pork's supply quantity and price, but reduce its demand prices in both urban and rural markets. In the short-run, when the supply is inelastic, urban consumers' demand, however, will decrease. Their welfare may be injured by the subsidy, allowing more welfare to be shared by rural consumers and pork farmers. For the market of other meats, the pork price subsidy effect does not seem significant, although prices and quantities of some commodities are influenced slightly. In the short-run, prices of other meat drop a little due to the increased demand of pork and the substitution effects. But in the long-run, the results are still counter-intuitive, prices and demands of other meat would also go up while the subsidy is on pork price. A plausible explanation is that Chinese consumers' demand for meat is still far from being satisfied. Anyway, the price subsidy seems effective in increasing benefits to producers and consumers, and could protect the domestic pork market from increased import pork.

We divide China's meats demand market into urban and rural, since the gap between urban and rural is most obvious and there are enough data to do this research. Still, we ignore the income differences between the urban and rural consumers. Although the growth rates are almost the same in recent years, the income gap keeps growing because of the base. A lot of factors that affect China's meat prices are ignored, such as effects of supply by animal diseases, or the increasing powerful stock market for pork and beef. Neither regional differences nor dynamics are taken into account in this thesis. And, we neglect imports and exports. The model would be more complicated but more improved by adding the world meat market, since China imports much more pork and beef than before, mainly from U.S. and Australia, due to its increasing meat demand. And, the WTO has reduced the tariff for accession into China's meat market, which could bring in more interests from U.S. farmers.

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Appendices

Appendix A

General Restrictions of Demand Analysis

Applied demand analysis is concerned with the estimation of the parameters of an equations system. The demand functions exhibit specific theoretical properties based on the assumptions used to derive the functions. These properties take the form of mathematical restrictions on the derivatives of the demand functions. Since these restrictions, include Engel aggregation (or Adding-up), Cournot aggregation, Slutsky symmetry, and homogeneity, must hold regardless of the form of the utility functions, they are commonly referred to as 'general restrictions'.

Each of the general restrictions defines an exact set of relationships connecting income and price slopes which any complete set of demand functions must possess if it is derivable from the maximization of any utility function. Under any of the representations, from the viewpoint of applied econometric analysis, the force of the classical theory amounts to a reduction in the dimension of the parameter space in a complete set of demand functions. Given n commodities, there exist n^2 price elasticites and n income elasticites, and so, $n(n+1)$ parameters require estimation. Econometric techniques require the number of observations to equal or exceed the number of parameters. The classical restrictions serve to reduce the dimension of the parameter space. This set of relationships provides $\left(n+1+\dfrac{n(n-1)}{2}\right)$ independent restrictions, and hence, the dimension of the parameter space dwindles from $n(n+1)$ to $\dfrac{n^2+n-2}{2}$. Of course, the economics of parameterization are not costless. All dynamic considerations are ignored, as are possible feedback from demand to prices and income.

Homogeneity (Absence of Money Illusion)

Every demand equation must be homogeneous of degree zero in income and prices. That is, if all prices and income are multiplied by a positive constant , the quantity demanded must remain unchanged (by Euler's theorem). Then, sum of all own and cross price elasticities with respect to commodity i has to be equal to minus its income elasticity.

$$\sum_j \eta_{ij} = -A_j \tag{A.1}$$

Adding-Up (Engel Aggregation)

The budget constraint has to be satisfied over the observed (or predicted) range of variation of prices and income. The demand equations have to be such that the sum of the estimated (or predicted) expenditures on the different commodities equals total expenditures in any period. Differentiate the budget constraint with respect to income:

$$\begin{aligned} p_i q_i = y \Rightarrow \sum_i p_i \frac{\partial q_i}{\partial y} = 1 \Rightarrow \sum_i (\frac{p_i q_i}{y})(\frac{\partial q_i}{\partial y})(\frac{y}{q_i}) = 1 \\ \Rightarrow \sum_i R_i A_i = 1 \end{aligned} \tag{A.2}$$

where R_i is the budget share of good i, and A_i is the expenditure elasticity for good i.

Cournot Aggregation ("Column sum")

Differentiate the budget constraint with respect to price for good j:

$$\begin{aligned} p_i q_i = y \Rightarrow \sum_i p_i \frac{\partial q_i}{\partial p_j} + q_j = 0 \Rightarrow \sum_i (\frac{p_i q_i}{y})(\frac{\partial q_i}{\partial p_j})(\frac{p_j}{q_i}) = -(\frac{p_j q_j}{y}) \\ \Rightarrow \sum_i R_i \eta_{ij} = -R_j \end{aligned} \tag{A.3}$$

where R_i is the budget share of good i, and η_{ij} is the price elasticity for good i with respect to the price of good j.

Slutsky Symmetry Conditions

The basic idea of the symmetry conditions is that the price derivatives of a demand equation can be decomposed into an income effect and a substitution effect. We start from the so-called Slutsky equation, which also bears the well-deserved name of "fundamental equation of the theory of value", of elasticity form:

$$\frac{\partial q_i}{\partial P_j} = (\frac{\partial q_i}{\partial P_j})^* - q_j \frac{\partial q_i}{\partial y}$$

The compensated cross-effects are symmetric, which implies $(\frac{\partial q_i}{\partial P_j})^* = (\frac{\partial q_j}{\partial P_i})^*$. Then we got the Hicksian symmetry restriction:

$$(\eta_{ij})^* = \frac{R_j}{R_i}(\eta_{ji})^*$$

And since $\eta_{ij} = \eta_{ij}^* - R_j A_i$, we derived the symmetry restriction for Marshallion elasticities:

$$\eta_{ij} = \frac{R_j}{R_i}\eta_{ji} + R_j(A_j - A_i) \tag{A.4}$$

where R_i is the budget share of good i, and A_i is the expenditure elasticity for good i.

Appendix B

Inflation Has No Effect: An Example of EDM's Basic Method

This part could also be treated as an introduction to establish EDM model. Consider a simple structural model with inflation:

$$\begin{aligned} Q_D &= D(P, \frac{Y}{r}) && \text{(Demand)} \\ Q_S &= S(P) && \text{(Supply)} \\ Q_D &= Q_S && \text{(Equilibrium)} \end{aligned} \tag{B.1}$$

where P is the equilibrium price, Y represents the nominal income, and $r = (1\text{+inlation rate}) \times 100\%$. Assumptions are set as follows:

a) Closed economy (No trade with outer world)

b) Perfect competition (Buyers and sellers are both price takers), and no government's intervention;

c) Y and r are exogenous;

d) Demand is downward sloping, and supply is upward sloping.

Starting with the demand equation, the change in Q_D could be determined by taking the total differential:

$$dQ_D = \frac{\partial Q_D}{\partial P} dP + \frac{\partial Q_D}{\partial (Y/r)} (\frac{1}{r} dy - \frac{Y}{r^2} dr)$$

Which upon converting to elasticities and relative changes, yields:

$$\frac{dQ_D}{Q_D} = \frac{\partial Q_D}{\partial P} \frac{P}{Q_D} \frac{dP}{P} + \frac{\partial Q_D}{\partial (Y/r)} \frac{(Y/r)}{Q_D} (\frac{dY}{Y} - \frac{dr}{r})$$

So, the demand equation in the EDM form:

$$EQ_D = \eta_P EP + \delta(EY - Er) \tag{B.2}$$

The same process upon supply and equilibrium equation, we get:

$$EQ_S = \varepsilon_P EP \tag{B.3}$$

$$EQ_S = EQ_D \tag{B.4}$$

where $E(X)$ represents the relative change in variable X, η_P is the price elasticity of demand, ε_P is the price elasticity of supply, and we call δ the elasticity of real income effect.

From the above displaced model, we can see that the inflation effect is just simply subtract the change of inflation rate from the increase of nominal income.

And we can easily get the following comparative statics (Reduced Form Elasticities):

$$\frac{EP}{EY} = \frac{\partial P/P}{\partial Y/Y} = \frac{Y}{P}\frac{\partial P}{\partial Y} = \frac{\delta}{-\eta_p + \varepsilon_p} \tag{B.5}$$

$$\frac{EP}{Er} = \frac{\partial P/P}{\partial r/r} = \frac{r}{P}\frac{\partial P}{\partial r} = \frac{-\delta}{-\eta_p + \varepsilon_p} \tag{B.6}$$

$$\frac{EQ}{EY} = \frac{\partial Q/Q}{\partial Y/Y} = \frac{Y}{Q}\frac{\partial Q}{\partial Y} = \frac{\varepsilon_p\delta}{-\eta_p + \varepsilon_p} \tag{B.7}$$

$$\frac{EQ}{Er} = \frac{\partial Q/Q}{\partial r/r} = \frac{r}{Q}\frac{\partial Q}{\partial r} = \frac{-\varepsilon_p\delta}{-\eta_p + \varepsilon_p} \tag{B.8}$$

Equations (B.5) – (B.8) shows that the effects of income growth is neutralized by the inflation ($\frac{EP}{EY} + \frac{EP}{Er} = \frac{EQ}{EY} + \frac{EQ}{Er} = 0$) if it is under the ideal condition that the inflation is totally caused by income growth, then the inflation rate is just equal to $\frac{\Delta Y}{Y}$.