Three Essays on the International Economic Development

by

Wei Ge

A dissertation submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Doctor of Philosophy

Auburn, Alabama
December 10, 2016

Keywords: Agricultural direct subsidy; Dutch disease;
Agriculture; Mining; Livestock inventory.

Approved by

Henry W. Kinnucan, Chair, Alumni Professor of Agricultural Economics
Yaoqi Zhang, Professor of Forest Economics
Diana Alessandrini, Assistant Professor of Economics
Mark Carpenter, Professor of Statistics

Abstract

This dissertation contains three essays as three chapters. The equilibrium displacement model (EDM) is employed to investigate the issues associated with the economic development in different context.

Chapter 1 analyses the incidence of the agricultural direct subsidy based on the data of China's wheat production from 2009 to 2011. The results show that the direct grain subsidy in China can increase both the domestic production and Chinese farmers' welfare, which are the main aims of the policy. The results also indicate that imports play an important role in the distribution of total welfare between producer surplus and consumer surplus. The producers will gain more from the subsidy if the net imports take a substantial share of China's wheat market. The increase in both the subsidy and the net imports will increase the net welfare loss in China. Thus, the Chinese government needs to adjust both imports and subsidy policy to let farmers get more benefits from the subsidy and at the same time avoid larger net welfare loss.

Chapter 2 examines the effect of the mining boom on Mongolia's agricultural sector, and in particular, tests whether currency strengthening associated with increased FDI reduced the size of Mongolia's trade-sensitive agricultural sector, as predicted by the Dutch Disease Hypothesis (DDH). Econometric analysis suggests each 1% increase in FDI increases the value of Mongolia's currency by 0.19% and each 1% increase in GNP increases the value of the currency by 0.34%, all else equal. Monte Carlo simulations of a Keynesian-style equilibrium displacement model of Mongolia's economy based on

these econometric estimates suggest the FDI-led mining boom had no effect on Mongolia's agricultural sector when exchange rate effects are taken into account. The 90% confidence interval for elasticity of agricultural value added with respect to FDI is [-0.082, 0.002] when exchange rate is endogenous. The corresponding 90% confidence interval when exchange rate is exogenous is [0.025, 0.129]. Although the DDH is rejected, the mechanism identified by the hypothesis clearly is important.

Chapter 3 studies the factors affecting the livestock inventory based on the panel data from 12 prefectures (or cities) in Inner Mongolia from 1980 to 2010. Specially, this study attempts to understand the dynamic changing of the inventory. Based on the livestock products market, an EDM is combined with an inventory equation to show the link between the livestock products market and the livestock inventory. The results indicate that compared to policy and weather status, prices of the livestock products play a more important role in the inventory of the livestock.

Acknowledgments

I would like to express the deepest appreciation to my committee chair, Dr. Kinnucan, for his academic advice, continuous support, understanding, patience and encouragement during my PhD study.

I would like to express my thanks to my committee members, Dr. Zhang, Dr. Alessandrini, and Dr. Carpenter, for their insightful comments and suggestions.

I would like to thank my country, China, for funding me to finish my PhD study.

I also would like to thank the faculty and staff who teach me and serve me, for their instructions and assistance; thank my colleagues and friends for their help in both my study and my life; thank my local American families for their kindness and friendliness.

In the end, the most importantly, I would like to thank my family for their encouragement and support.

Table of Contents

List of Figures

List of Tables

Chapter 1. The Incidence of China's Direct Grain Subsidy

1. Introduction

China is one of the most important agricultural countries in the world. Before 2004, it was the only country which still levied a tax on agriculture all around the world. As the agricultural production decreased over several years, and the income gap between rural and urban households continued to grow, in 2004 the Chinese government decided to implement a subsidy policy for agriculture and eliminate agricultural tax which had existed for more than 2000 years. Thus the subsidy policy is a milestone in the history of China. To the present, the government provides four kinds of subsidies: direct subsidy for grain, seed subsidy, comprehensive direct subsidy for means of agricultural production, and farm machinery purchase subsidy. Direct subsidy for grain is a direct payment for per acre planted with a specific kind of grain. Seed subsidy is paid if the farmers buy high-quality grain or soybean seeds from authorized seed companies, and usually this kind of subsidy is redeemed after the farmers get the receipts. Comprehensive direct subsidy for means of agricultural production is used to subsidize farmers when the prices of the means of agricultural production (like diesel, fertilizer, etc.) go up. Farm machinery purchase subsidy is provided for the purchase of certain machines. Among these subsidies, the direct subsidy for grain together with the comprehensive direct subsidy for means of agricultural production are called "direct grain subsidy", and the amount paid to farmers is directly based on the area planted. The direct grain subsidy takes more than 50% of the total agricultural subsidy and is the main subsidy to increase farmers' income and spur agricultural production. The direct grain subsidy has been increasing significantly in recent years. The total agricultural subsidy was 19.05, 18.32 and 21.02 billion dollars, and the direct grain subsidy was 12.96, 12.96 and 15.11 billion dollars in

2009-2011 respectively. The share of the direct grain subsidy in the total subsidy increased from 68.03% in 2009 to 72% in 2011. The effect of the subsidy policy is substantial as the production of grain in China increased from 53.08 million tons to 58.96 million tons during the three years. At the same time, the grain imports also increased when the production went up. Some scholars analyzed the phenomenon. For example, Wu and Hu (2007), and Huang (2004) considered that China should make good use of trade to improve its own agriculture; however, Wang (2008), who emphasized the importance of self-sufficiency in grain and analyzed the reasons for the increase of imports, he suggested the larger consumption in China, and their disadvantages, for example harming the domestic wheat producers and threatening the self-sufficiency of wheat. Thus, the effect of the trade is also of interest to me. The direct grain subsidy is the most important part of the subsidy policy. Both the substantial effect of the direct grain subsidy on the Chinese market and the interaction between the direct grain subsidy and the imports get lots of attention. This paper will analyze the incidence of the direct grain subsidy as well as the role of imports during the implementation of the subsidy.

Wheat is one of the most important grains in China and it is also the staple food in the north of China. According to the policy, wheat is the key grain subsidized[1]. Table 1.1 shows the general situation of the Chinese wheat market in the world. Both the consumption and the production of Chinese wheat took great proportions of the world total quantities from 2009 to 2013. Table 1.1 also shows that China was an importer of wheat and the amount increased during the five years. As a large importer of wheat, China's subsidy policy will also impact the wheat market in the world. This paper chooses wheat[2], which is a typical kind of grain subsidized, to examine the incidence of

[1] Wheat, rice and corn are the main crops subsidized.

[2] The reason to use wheat as the commodity in this paper is the limitation of the data

the direct grain subsidy in both the domestic market and the international market.

In a perfectly competitive market with no distortions, theory indicates that a subsidy creates a wedge between the supply price and the demand price. The purpose of this paper is to determine the incidence of the direct grain subsidy in the Chinese wheat market and in the rest of the world (ROW), and in particular, to determine how a single percent increase of the direct grain subsidy could be split between Chinese consumers and producers. This paper focuses on the effect of the direct grain subsidy on producers, because the primary aim of the subsidy policy is to increase farmers' income and agricultural production. The analysis will show how the welfare is distributed between consumers and producers. This research is also important for policymakers: it will explain how to implement the policy efficiently, whether farmers get benefit from the direct subsidy as expected, how to increase their profit from the subsidy, how to deal with the growing imports, and whether imports threaten domestic wheat market or not.

The rest of the paper is organized as follows: section 2 provides a review of previous studies; section 3 discusses the direct grain subsidy; section 4 presents the model that is used to simulate the effect of the direct grain subsidy on the Chinese wheat market and China's imports of wheat; section 5 discusses how one percentage increase of the direct grain subsidy impacts the prices of wheat, consumption and production; section 6 discusses the welfare effect of the direct grain subsidy; section 7 concludes.

2. Literature Review

Given the importance of the new agricultural policy in China, many scholars have been interested in its effect and efficiency. Scholars are mainly concerned about the effect of the direct grain subsidy on production and farmers' income, because these are the main purposes of the policy. Wang and Xiao (2006) used the Positive Mathematical Programming (PMP) model and household-level data from Hebei, Henan and Shandong province in China to examine the effect of the direct grain subsidy. They found that the direct grain subsidy increased the agricultural production and farmers' income, but the effect was not significant because the amount was small, and the government should increase the subsidy. Li and Tan (2006) analyzed the effect of the direct grain subsidy on farmers' income in Anhui province, China, and also found that the subsidy increased farmers' income. However the effect was not significant because the quantity of the subsidy was small. Chen et al. (2010) analyzed the effect of the direct grain subsidy on the agricultural production based on the province-level data from 2004 to 2007, and found that the subsidy increased the production by increasing the investment of land and capital. Wu and Lu (2011) examined the effect of the direct grain subsidy on increasing grain production and farmers' income through a simulation study based on a survey, and showed that the promotion effect of the subsidy increased significantly as the subsidy increased, so it was reasonable to increase the subsidy. Huang et al. (2011) did a survey about the direct grain subsidy for more than 1000 households in six provinces of China, and the survey indicated that the direct grain subsidy increased the production. Ma and Zhang (2012) examined the effect of the subsidy policy on farmers' income from 2004 to 2008 by developing a grey correlation analysis, and found that the effect was not significant. They treated the subsidy policy as a dummy variable which was equal to 0 for 1996-2003 and 1 for 2004-2008 in their analysis. Since they ignored the increase of the subsidy every year, the result, that the effect was not significant, was not completely precise. There is still extensive research indicating that the direct grain subsidy increases the production and farmers' income, (e.g. Li and Xiao (2006), Zhan (2009)). Based on the previous studies, the direct grain subsidy can increase the production and farmers' income as expected.

According to economic theories, subsidy impacts the prices in the market and generates the difference between demand price and supply price. Meanwhile, it affects the consumption and production, and then changes the welfare distribution which also reflects the changes in farmers' income. Huang et al. (2010) constructed the general equilibrium model (CGE) to analyze the effect of the agricultural subsidies in China, and found that growth in agricultural subsidies would reduce demand price and stimulate household consumption. Wang and Ge (2009) examined the welfare effect of the direct grain subsidy using the welfare economics theory, and found that the distribution of the welfare from the direct grain subsidy benefited consumers more than farmers, because the supply elasticity was larger than the demand elasticity. Xiao (2005) also found that the consumers gained more benefits than the farmers from the direct grain subsidy. Ye and Wang (2005) used the data envelope analysis (DEA) model to study the subsidy efficiency from "the system efficiency" and "the scale efficiency", and they found that the efficiency of the Chinese grain subsidy system was not generally high. He (2006) also found that the cost of the direct grain subsidy was large, and the subsidy generated large deadweight loss. Yu and Jensen (2010) used a computable general equilibrium framework to examine the effect of China's agricultural subsidy policy, and the simulation results suggested that the subsidy policy achieved the declared policy goals of increasing grain production and boosting farm income by more than 10%. Hansen, Tuan and Somwaru (2011) developed a 42-country partial equilibrium global dynamic agricultural simulation model to analyze the effect of China's policy including the subsidy on the international trade, and showed that recent agricultural policy reforms decreased the domestic prices to consumers and increased China's production slightly, causing imports to decrease.

The direct grain subsidy in China is a kind of production subsidy which is common in developing or less developed countries. Hedley and Tabor (1989) did a static welfare analysis of the fertilizer subsidy in Indonesia, and showed that the farmers only received 7% of the financial subsidy. Chibwana et al. (2012) used a two-step regression to measure the impacts of Malawi’s Farm Input Subsidy Program on the cropland allocation decisions of farmers in Kasungu and Machinga districts in central and southern Malawi, and found that participants in the program increased the land planted with maize and tobacco, and as a result, the production of maize and tobacco went up. Razack et al. (2009) analyzed the effects of the agricultural production subsidy in India by developing a computable general equilibrium (CGE) model by incorporating Harris-Todaro economic characteristics of unemployment, labor migration, farm-dependant population, and labor-intensive agriculture, and they found that agricultural production subsidy increased agricultural production, reduced unemployment, as well as augmented the consumption.

Based on the review above, the production subsidy increases production, farmers’ income, welfare, prices; the effect is different for consumers and producers; and the effect is different with different scales of the subsidy. Subsidy policy works through markets, so the effect of the subsidy depends on the markets. Elasticities in a market decide the changes of prices, consumption, and production, and then the distribution of welfare between consumers and producers. Guyomard et al. (2004) showed that the elasticities were very important to determine the ranking of these four subsidies: an output subsidy, a land subsidy, and a decoupled payment with and without mandatory production. According to Guyomard et al. (2004), the direct grain subsidy is equivalent to a land subsidy in their study because the land subsidy is also given based on the area planted. The previous research about the effect of China’s direct grain subsidy mainly showed some qualitative results (e.g. whether the subsidy increases the production and farmers’ income or not, whether it impacts the welfare and prices or not). Most of the research does not analyze the quantitative changes of the production, consumption, farmers' income, welfare, and prices except Yu and Jensen (2010). However, quantitative analysis is important for the subsidy policy. The main difference between Yu and Jensen (2010)'s work and the current study is that the models are different. Yu and Jensen used a computable general equilibrium model which was a modified version of the well-known global GTAP model. Their model didn't show the change of the government cost. The import of some grains including wheat increases every year in China. Ke (2007), Zhu (2007) and Cheng (2005) indicated that China will depend on imports to ensure food security for a long time. Zhong and Cao (2011) analyzed the consumption, production and international trade of wheat in China, and pointed out that China must insist on the policy of self-supply firstly and import secondarily, as well as increasing wheat yield and thus promoting sound and sustained development of wheat industry. So it is necessary to consider the role of imports when analyzing the effect of the direct grain subsidy in China, which is an important wheat importer in the world. This paper will do a sensitivity analysis using the equilibrium displacement model (EDM) in an open market so it will fill up the gap in the literature. The EDM is a useful tool in agricultural economics and it examines the effect of agricultural policies based on the elasticities in the market. It meets the need to analyze the effect of the direct grain subsidy on prices, consumption, production, imports and welfare in China's wheat market. Due to the data availability, the analysis in this paper is limited to years 2009 to 2011.

3. China's Direct Grain Subsidy

As described in the first section, China's agricultural subsidy system consists of four kinds of subsidies: direct subsidy for grain, seed subsidy, comprehensive direct subsidy for means of agricultural production, and farm machinery purchase subsidy. Direct subsidy for grain together with the comprehensive direct subsidy for the means of agricultural production is called “the direct grain subsidy” officially in China. The direct grain subsidy, which takes more than 50% of the total agricultural subsidy, is the key subsidy in agriculture industry. It is indispensable to know the direct grain subsidy before analyzing its effect.

This section begins with farmers' profit function. Suppose there are two input factors: land (L) and other capitals (K); therefore, the production function will be $Q(L,K)$. As the direct grain subsidy is based on the area planted, the direct effect of this subsidy is decreasing the price of the land.

Then the profit function per acre for the farmers who get the subsidy is:

$$\max_{L,K}\Pi = PQ(L,K) - (P_L - S_0) * L - P_K K$$

Where L and K represent land and other capitals input; Π represents profit; P, P_L and P_K represent the prices of the specific crop (wheat in this paper), the cost of land and the cost of other capitals respectively; S_0 is the direct grain subsidy per acre.

To maximize the profit, the input of land and other capitals should satisfy the conditions below.

FONCs:

(1) $\frac{\partial\Pi}{\partial L} = Pf_L - (P_L - S_0) = 0 \Longrightarrow P * MP_L = P_L - S_0 \quad (f_L = \frac{\partial Q(L,K)}{\partial L})$

(2) $\frac{\partial\Pi}{\partial K} = Pf_K - P_K = 0 \Longrightarrow P * MP_K = P_K \quad (f_K = \frac{\partial Q(L,K)}{\partial K})$

SONCs:

(3) $\frac{\partial^2\Pi}{\partial L^2} = Pf_{LL} \leq 0$

(4) $\frac{\partial^2\Pi}{\partial K^2} = Pf_{KK} \leq 0$

(5) $\frac{\partial^2\Pi}{\partial K\partial L} = \frac{\partial^2\Pi}{\partial L\partial K} = Pf_{KL}$

(6) $\frac{\partial^2\Pi}{\partial L^2} * \frac{\partial^2\Pi}{\partial K^2} - \frac{\partial^2\Pi}{\partial K\partial L} * \frac{\partial^2\Pi}{\partial L\partial K} = P^2 f_{LL} f_{KK} - P^2 {f_{KL}}^2 > 0$

From the FONCs (1) and (2), the implicit demand function for land (L) and other capitals (K) can be obtained. At the optimal point:

(7) $\bar{L} = \bar{L}(P^0, P_L^0, P_K^0, S_0)$

(8) $\bar{K} = \bar{K}(P^0, P_L^0, P_K^0, S_0)$

And the total differentials of the FONCs are:

(9) $P^0(f_{LL} d_L + f_{LK} d_K) = -d_{S_0}$

(10) $P^0(f_{KL} d_L + f_{KK} d_K) = 0$

So

(11) $\frac{d_{\bar{L}}}{d_{S_0}} = \frac{f_{KK}}{-P^0 f_{LL} f_{KK} + P^0 f_{KL}{}^2}$

(12) $\frac{d_{\bar{K}}}{d_{S_0}} = \frac{-f_{KL}}{-P^0 f_{LL} f_{KK} + P^0 f_{KL}{}^2}$

Based on the total differentials (11) and (12), comparative statics analysis can be done about land ($\bar{L}$), other capitals ($\bar{K}$) and subsidy (S_0). Based on Hessian matrix, the SONCs give: $f_{KK} \leq 0$, $f_{LL} \leq 0$ and $f_{LL} f_{KK} - f_{KL}{}^2 > 0$, both the numerator and denominator of $\frac{d_{\bar{L}}}{d_{S_0}}$ are negative so $\frac{d_{\bar{L}}}{d_{S_0}} > 0$. The subsidy will increase the input of land. The denominator of $\frac{d_{\bar{K}}}{d_{S_0}}$ is negative so the sign of $\frac{d_{\bar{K}}}{d_{S_0}}$ depends on f_{KL} which is the technical interrelationship between land and other capitals, and indicates the effect of land on the marginal productivity of other capitals. If it is positive, it means that the marginal productivity of other capitals is enhanced at all levels as land is increased, and then land and other capitals are technically complementary; if it is negative, increasing land will reduce the marginal productivity of other capitals, and then land and other capitals are technically competitive; if it is equal to 0, land and other capitals are technically independent, and changes of land have no effect on the marginal productivity of other capitals. Usually, the marginal productivity of land will be enhanced as the other factors are increased, and vice versa, so land and other capitals are technically complementary factors. Thus, $f_{KL} = f_{LK} > 0$ and then $\frac{d_K}{d_{S_0}} > 0$. The subsidy also increases the input of other forms of capital. Subsidy increases the investment of production factors, and then affects the cost as well as the supply price of the crop. This is the origin of the difference between demand price and supply price in the market. In China, the wheat production per acre was 1917.85kg, 1921.65kg and 1957.59kg in 2009, 2010 and 2011 respectively. The productivity is almost stable, so it is assumed that the production of wheat per acre does not change in the three years. Since farmers are subsidized based on the area planted with wheat and the production per acre does not change, the direct grain subsidy will affect the cost of the wheat per kg in the market. The direct grain subsidy is assumed to be per-unit.

According to the analysis of the profit function, farmers are subsidized based on their land, so the subsidy is actually an input subsidy. In order to analyze the effect of an input subsidy on the wheat market, it is necessary to know the effective subsidy which is the effect of the input subsidy on the final commodity—the wheat. Table 1.2 contains cost information of wheat per acre. Based on table 1.2, the effective subsidy ratio is equal to the land cost ratio times the subsidy ratio. The land cost ratio is the proportion of land cost in the total cost and the subsidy ratio is the proportion of the direct grain subsidy in the cost of land, so the value of the effective subsidy ratio is equal to the direct grain subsidy divided by the total cost. The effective subsidy ratios are 10.18%, 9.17% and 9.14% in 2009, 2010, and 2011. The effective subsidy ratio decreased during the three years as the cost of land went up.

4. Model

To qualify the effect of the subsidy, an Equilibrium Displacement Model (EDM) of China's wheat market is employed to focus on the important partial elasticities, quantities, and expenditure shares to calculate the relative importance of the policy on market equilibrium outcomes, and lends itself to applied welfare analysis. In the models, it is assumed that there are two regions in the world, China and the ROW. Wheat from China and the ROW are assumed to be homogenous goods or perfect substitutes. Wheat prices are determined under conditions of perfect competition. Subsidy (S) is the exogenous variable which disturbs the wheat market and affects the welfare of different parts in the market. Table 1.1 shows the demand, supply and net imports of wheat in China. From 2009 to 2013, China consumed more than 15% of the total wheat consumption in the word so it is a large importer of wheat. As wheat is a necessity, its demand and supply curves have normal slopes. In order to simplify our analysis, it is assumed that the demand price (P_d) is the same in both the domestic market and the ROW in equilibrium, and it affects demand quantities (Q_d) in the domestic market and net imports (Q_m) in the ROW. Domestic supply price (P_s) affects the domestic supply quantities (Q_s).

The supply price is higher than the demand price because of the subsidy:

(13) $P_s = P_d + S$

Where P_s is China's supply price, P_d is the demand price, and S is the per-unit direct grain subsidy of wheat. The percentage effect of changes in the subsidy on the supply price in China can be determined by taking the total differential of equation (13) and dividing by $\mathrm{P_s}$ to yield:

$$\frac{dP_s}{P_s} = \left(\frac{P_d}{P_s}\right)\frac{dP_d}{P_d} + \left(\frac{S}{P_s}\right)\frac{dS}{S}$$

The above equation can be expressed more simply as:

(14) $P_s^* = (1 - \tau_s)P_d^* + \tau_s S^*$

Where the asterisk indicates relative change ($P_d^* = \frac{dP_d}{P_d}$ and $S^* = \frac{dS}{S}$); $\tau_s = \frac{S}{P_s}$ is the effective subsidy ratio.

The structural models for the wheat market are below:

(15) $Q_d = D(P_d)$

(16) $Q_s = S(P_s)$

(17) $Q_m = M(P_d)$

(18) $Q_d = Q_s + Q_m$

Where, Q_d is the domestic consumption; Q_s is the domestic production; Q_m is the net imports from the ROW. This model [equations (13) and (15)-(18)] contains five endogenous variables (P_d, P_s, Q_d, Q_s and Q_m) and one exogenous variable (S). Here, wheat is assumed to be strictly separate from all other goods and exogenous variables other than the subsidy, and shipping costs are suppressed.

To determine the incidence of the direct grain subsidy, first express equations (15)-(18) in percentage changes to yield:

(19) $Q_d^* = \eta_d P_d^*$

(20) $Q_s^* = \varepsilon_d P_s^*$

(21) $Q_m^* = \varepsilon_m P_d^*$

(22) $Q_d{}^* = k_d Q_s{}^* + k_m Q_m{}^*$

Where $\eta_d (< 0)$ is the domestic demand elasticity for wheat; $\varepsilon_d (> 0)$ is the domestic supply elasticity; $\varepsilon_m (> 0)$ is the import supply elasticity; k_d is the China quantity share; and k_m is the ROW quantity share. As it is assumed that there are two regions of wheat in the world, $k_d + k_m = 1$.

Dropping equations (14) and (20) (treat P_d and P_s as temporarily exogenous) and solving the remaining equations simultaneously for Q_s^* yields:

(23) $Q_s^* = \eta_s P_d^*$

Where:

(23a) $\eta_s = \frac{\eta_d - k_m \varepsilon_m}{k_d}$

can be regarded as the sensitivity of the domestic supply to the demand price. From equation (23a), $\eta_s < 0$. It becomes more elastic as: (i) China's consumers or producers from the ROW become more sensitive to the price (a larger η_d in absolute value or a larger ε_m); and (ii) China imports more wheat or produces less.

Setting domestic demand equal to domestic supply [equation (23) =equation (20)] and substituting equation (14) yields the desired expressions for the changes of both demand price and supply price in China's wheat market:

(24) $P_d^* = \frac{\tau_s}{\omega - (1-\tau_s)} S^*$

(25) $P_s^* = \frac{\omega \tau_s}{\omega - (1-\tau_s)} S^*$

Where

(26) $\omega = \frac{\eta_s}{\varepsilon_d} = \frac{\eta_d - k_m \varepsilon_m}{k_d \varepsilon_d}$

The ratio ω indicates the comparison between the sensitivity of domestic supply to the demand price and that of domestic supply to the supply price. ω is less than 0 since $\eta_s < 0$ and $\varepsilon_d > 0$. Then, because $0 < \tau_s < 1$, the demand price will decrease and the supply price will increase when the subsidy increases. When $\omega = -1$, the domestic supply is as sensitive to the supply price as to the demand price, the rise in the supply price will be equal to the fall in the demand price; when $-1 < \omega < 0$, the domestic supply is more sensitive to the supply price than the demand price, the decrease of demand price is larger than the increase of supply price, and consumers get more benefits from the subsidy than the producers; and when $\omega < -1$, the domestic supply is less sensitive to the supply price than the demand price, the decrease of demand price is smaller than the increase of supply price and the producers get more benefits from the subsidy than the consumers. When ω is negative infinity, all the changes of subsidy becomes the producers' welfare. Since the elasticies depend on the situations in the market and seldom change in a short time, the import may play an important role to adjust the ratio which affects the effect of the direct grain subsidy on demand price and supply price. According to equation (26), the increase in imports will decrease ω, the increase in the supply price will go up and producers will gain more from the subsidy. When the proportion of import is 2.42%, ceteris paribus, the value of ω is -1.

Substitute equations (24) and (25) into equations (19), (20), and (21), and then get the changes of domestic demand, domestic supply, and imports:

(27) $Q_d^* = \frac{\eta_d \tau_s}{\omega-(1-\tau_s)} S^*$

(28) $Q_s^* = \frac{\varepsilon_d \omega \tau_s}{\omega-(1-\tau_s)} S^*$

(29) $Q_m^* = \frac{\varepsilon_m \tau_s}{\omega-(1-\tau_s)} S^*$

As analyzed previously, the subsidy will increase supply price and decrease demand price, though the increase may not be equal to the decrease in absolute values. The changes of price will increase both domestic supply and demand. But the decrease of the demand price makes imports go down. The important parts are the changes of welfare, especially domestic producers' welfare, because the Chinese government tries to implement the subsidy policy to increase the farmers' welfare.

Figure1.1 shows the effect of the direct grain subsidy on the equilibrium. The original demand curve and supply curve in China are denoted by D and S^0, and the original excess demand curve and excess supply curve in the ROW are ED^0 and ES. Since the direct grain subsidy increases every year, S_1 and S_2 represent different amounts of subsidy. The original price, demand, supply, and imports are P_0, Q_d^0, Q_s^0 and Q_m^0 respectively. The direct grain subsidy S_1 shifts the supply curve from S^0 to S^1 and the excess demand curve shifts from ED^0 to ED^1. Consequentially the demand price decreases from P_0 to P_d, the actual supply price increases from P_0 to P_s, the domestic demand increases from Q_d^0 to Q_d , the domestic supply increases from Q_s^0 to Q_s, and the import decreases from Q_m^0 to Q_m. The difference between P_d and P_s is the subsidy S_1. When the subsidy increases from S_1 to S_2, the demand price and the import continue to decrease, and meanwhile the supply price, the domestic demand, and the domestic supply continue to increase. The demand price, supply price, domestic demand, domestic supply, and import become P_d', P_s', Q_d', Q_s' and Q_m' after the subsidy increases from S_1 to S_2. The difference between the demand price and the supply price becomes S_2. P_d'' parallels P_d and it helps to calculate the change of domestic producer surplus. The changes of all the variables indicated in the figure are corresponding to the results from the analysis of equations (24), (25), (27), (28), and (29).

This paper follows Sun and Kinnucan (2001)'s method to obtain the producer and consumer surplus. Figure 1.2 shows the changes of welfare when the subsidy increases more clearly. In the domestic market, the change of consumer surplus (ΔCS) is labeled by the areas F, G, H, and I, and the change of producer surplus (ΔPS_1) is labeled by the areas J and K; the change of producer surplus (ΔPS_2) in the ROW is labeled by the areas L and M; the total change of welfare in China (ΔTS) is the sum of the change of consumer surplus (ΔCS) and the change of producer surplus (ΔPS_1); the government affords the increase of this subsidy (ΔG), which is labeled by the areas A, B, E, F, and G:

$$\Delta CS = (P_d - P_d') * Q_d + \frac{1}{2}(P_d - P_d') * (Q_d' - Q_d)$$

$$\Delta PS_1 = (P_d' - P_d'') * Q_s + \frac{1}{2}(P_d' - P_d'') * (Q_s' - Q_s)$$

$$\Delta PS_2 = -(P_d - P_d') * Q_m' + \frac{1}{2}(P_d - P_d') * (Q_m - Q_m')$$

$$\Delta TS_d = \Delta CS + \Delta PS_1$$

$\Delta G = Q_s' * (P_s' - P_d') - Q_s * (P_s - P_d)$

The changes of welfare can be expressed more clearly with the changes of prices and quantities (the process see appendix):

(30) $\Delta CS = -P_d * Q_d * P_d{}^* * \left[1 + \frac{1}{2} * Q_d{}^*\right]$

(31) $\Delta PS_1 = -P_d * Q_s * \left(-\frac{\tau_s}{(1-\tau_s)} S^* - P_d{}^*\right) * \left[1 + \frac{1}{2} * Q_s{}^*\right]$

(32) $\Delta PS_2 = P_d * Q_m * P_d{}^* * [1 + \frac{1}{2} * Q_m{}^*]$

(33) $\Delta TS = \Delta CS + \Delta PS_1$

(34) $\Delta G = Q_s P_s P_s^*(Q_s^* + 1) - Q_s P_d P_d^*(Q_s^* + 1) + Q_s Q_s^* * (P_s - P_d)$

Until now, the incidence of the direct grain subsidy on the prices, supply, demand, and welfare in both China and the ROW has been obtained through the models. According to the results from the models and the graphical analysis comprehensively, several hypotheses are proposed:

(a) The increase of the direct grain subsidy will increase domestic consumption, domestic production, and supply price, and decrease imports and demand price.

(b) Imports will affect the incidence of the direct grain subsidy on demand price and supply price in a short period. The increase in imports will make producers gain more from the increase in the direct grain subsidy.

(c) The increase in the direct grain subsidy will decrease the welfare of the producers in the ROW, and increase the welfare of the domestic consumers and producers.

In the following two sections, the results from the models will be applied to the wheat industry in China to test the hypotheses above.

5. Application to the Wheat Industry in China

Before analyzing the effect of the subsidy on welfare, it is better to know the effect of the direct grain subsidy in China's wheat market generally. Table 1.2 shows the total production, cost, and subsidy of wheat per acre in China from 2009 to 2011. The data are from or calculated based on the China Rural Statistical Year Book. In order to make the data comparable, the average exchange rate of the three years, 6.69 [3]CNY/USD, is used to covert Chinese Yuan to US Dollar. As shown, both total production and total cost increased obviously in the three years. The total production of wheat was $624.54, $681.25, and $753.42 per acre, and the total cost was $514.40, $561.32, and $646.41 in 2009, 2010, and 2011 respectively. There is no data on the subsidy for wheat per acre after 2008, except the government's total payment on the direct grain subsidy every year. The total direct grain subsidy in 2009, 2010 and 2011 was 190.51 million dollars, 183.24 million dollars, and 210.16 million dollars. Here it is assumed that the proportion of the direct grain subsidy on wheat does not change, and then obtain the direct grain subsidy on wheat from 2009 to 2011. The direct grain subsidy of wheat per acre was $53.57, $51.52, and $59.09. The subsidy of wheat per acre decreased by 4% and increased by 15% as the government's payment on total direct grain subsidy changes in 2010 and 2011. The increase in the subsidy was significant during 2011. The land cost ratio increased from 18.32% to 19.63% and then decreased to 18.15% from 2009 to 2011. The effective subsidy ratio fell from 10.41% to 9.18% during 2010 and then to 9.14% during 2011. Compared to the effective subsidy ratio in 2004, which was just 1.46%, it increased fast at the beginning and then became stable after 2009. Table 1.1 shows China's wheat market compared to the ROW wheat market. The total consumption of wheat in China was 107.0MMT[4], 110.5MMT, and 122.5MMT from 2009 to 2011 respectively, and it increased sharply from 2010 to 2011. The total production of wheat was 115.1MMT, 115.2MMT, and 117.4MMT in 2009, 2010 and 2011 respectively. The total production of

[3] Source: China Statistical Yearbook 2012

[4] MMT: Millions of Metric Tons.

wheat increased more moderately than total consumption. In the world market, China is a large importer of wheat and China's net imports of wheat were 0.5 MMT, 0 MMT, and 1.9 MMT in 2009, 2010, and 2011. Tables 1.1 and 1.2 give a general view of the development of the wheat industry in China. The details of changes of price, demand, supply, and import are in the following part.

Apply equations (24), (25), (27), (28), and (29) to China's wheat subsidy using baseline values for 2009-2011, as given in table 1.3. Elasticities here are from Zhuang and Abbott (2007)'s study, where they used the AIDS model of food demand to estimate the elasticities for consumption, feed demand, production, and foreign demand or supply faced in China. Compared to previous studies (Rozelle and Huang (2000), Hsu et al. (2002), Halbrendt et al. (1994), Liu and Chern (2001), Gao et al. (1996)), Zhuang and Abbott (2007) used time series data covering a period of more than 20 years and variables including household income as well as per capita consumption, and prices were at national level. This paper analyzes the effect of subsidy in China, which is at the national level, and the assumption that there are two regions in the world, China and the ROW, in Zhuang and Abbott (2007)'s study is corresponding to the assumption in this paper. So, the elasticities from Zhuang and Abbott (2007)'s study are suitable for our study. The results of application to China's wheat are obtained in table 1.4. The effective subsidy ratios are different in different years. In order to figure out the effect of subsidy and compare the changes associated with different effective subsidy ratios, three groups of values are calculated for the variables in 2009, 2010, and 2011 respectively when the subsidy increases by 1%.

In general, the results verify the hypotheses from the models that the subsidy increases the supply price, domestic consumption, and domestic production, and decrease the demand price and the imports. Meanwhile the results are consistent with the previous studies that the impact of subsidy on production and prices is low. In 2009 and 2010, the decrease of the demand price is larger than the increase of the supply price. This means that domestic consumers get more benefits from the direct grain subsidy than the domestic producers. The results obtained from China's wheat market are corresponding to the analysis of equations (24) and (25). Based on China's reality, ω is equal to -0.81 and -0.76 in 2009 and 2010. As analyzed previously, when $-1 < \omega < 0$, it means the domestic supply is more sensitive to the supply price than the demand price, and in this case the decrease of demand price is larger than the increase of supply price, and consumers get more benefits from the subsidy than the producers. The producers will get more benefits from the subsidy than the consumers if $\omega < -1$. Based on the calculation, -0.81 and -0.76 are less than, but close to -1. China's government needs to adjust ω to increase farmers' benefit more than the consumers', since that is the main aim of the subsidy policy. According to equations (23a) and (26), $\omega = \frac{\eta_d - k_m \varepsilon_m}{k_d \varepsilon_d}$, so China can implement some policies together with the subsidy policy to adjust the wheat market and let farmers get more benefit from the policy through either decreasing demand elasticity, increasing import supply elasticity, decreasing domestic supply elasticity or increasing imports to make ω approach -1. As said before, it is hard to adjust elasticities in a market in a short time. Wheat is a necessity and its demand is less elastic. Thus increasing imports might be a better method. The results from 2011 provide good evidence. In 2011, the imports increase to 1.9 MMT from 0 in 2010 and the ω becomes -0.91. The decrease of the demand price is almost equal to the increase of the supply price. This indicates that an appropriate increase of net imports will make farmers benefit more from the policy. From the detailed analysis of the changes of prices and quantities, the effect of the subsidy on imports is the most significant, followed by the effect on the prices. The effects of the subsidy on the domestic consumption and the domestic production are not as significant as the effect on imports and prices. Although the decrease of the demand price is more than the increase of the supply price, it is hard to say that the consumers will gain more from the direct grain subsidy policy than the producers totally, because the total consumption and production also change.

6. Welfare Effect of the Direct Grain Subsidy

According to the equations (30)-(34), data from 2009, 2010, and 2011 as the baseline values (table 1.5) is used to calculate the changes of the welfare when the subsidy increases by 1% each year. The changes of prices and quantities have already been in table 1.4 when the subsidy increases by 1%. The changes of welfare each year are shown in table 1.6. The numbers in the brackets indicate the proportion change. For example, in 2009, the consumer surplus increased by 18.07 million dollars when the subsidy increased by 1%. 18.07 million dollars is 0.0611% of the total consumer expenditure in 2009. Under the circumstance in 2009, when the subsidy increases by 1%, the producer surplus in China will increase 17.53 million dollars. This indicates that the subsidy policy will benefit both consumers and producers in China. Still, consumers gain more from the policy. The total consumer expenditure will increase by 0.0611% and the total revenue will increase by 0.0551%. The government will need to pay 38.46 million dollars more to support the increase of consumer surplus and producer surplus and it will generate a net welfare loss of 2.87 million dollars in China. The producer surplus from the ROW decreased by 0.08 million dollars, which is little, so this policy mainly impacts the domestic market. In 2010, the effective subsidy ratio decreased by 11.8% and the ω increased by 6% since there were no imports. In this case, the consumer surplus increased by 17.97 million dollars, which is 0.0549% of the total consumer expenditure and the producer surplus increased 15.73 million dollars, which is 0.0461% of the total revenue in China. Both consumer surplus and producer surplus increased less in 2010 than 2009 when the subsidy increased by 1%, because China's government decreased the total agricultural subsidy in 2010. There is no welfare loss for the producers from the ROW since there are no net imports. The government's payment also decreased from 38.46 million dollars to 36.30 million dollars. The net welfare loss in China fell down. This means that the policy was more efficient in 2010 than 2009, though the increase of total surplus is not as much as that in 2009. In 2011, the effective subsidy ratio did not change a lot, but China increased its net imports. When the subsidy increases by 1%, the consumer surplus increases by 19.10 million dollars, which is 0.0502% of the total consumer expenditure; and the domestic producer surplus increases by 18.41 million dollars, which is 0.0505% of the total revenue. The increases of consumer surplus and producer surplus are the largest among the three years, and so is the government payment. What is more important is that the proportion change of total revenue is larger than that of the consumer expenditure. In other words, farmers in China begin to gain more than the consumers from the subsidy in 2011 based on the proportion changes. The net welfare loss is 2.47 million dollars which is the least in the three years. The policy becomes more efficient in 2011. The producer surplus from the ROW will decrease by 0.3 million dollars which is the largest during the three years because the net imports are the largest in 2011.

From the analysis, the increase of consumer surplus is always larger than the increase of producer surplus during the three years in China. In 2011, the proportional increase of producer surplus exceeds that of consumer surplus. The effective subsidy ratio is similar in 2010 and 2011, and the main difference between the scenario in 2010 and that in 2011 is that there are no net imports in 2010. The increase of net imports will decrease the value of ω, and then the increase of the supply price will exceed the decrease of the demand price, so producers get more benefit from the change of the subsidy. Refer to the welfare analysis, the increase of net imports also enhance the welfare of the domestic producer. Both net imports and subsidy impact the welfare. The increase of subsidy will enhance the quantities of the welfare and the net imports will affect the distribution of the welfare. In order to verify this assumption, six scenarios are designed for 2011 artificially. In each scenario the direct grain subsidy will increase by 1% as discussed before. The results are shown in table 1.7. Scenario 1-6 represent the situations when net imports increase by 10%, 20%, 30% and the subsidy increases by 10%, 20%, 30% respectively with other variables constant. As the net imports increase from scenario 1 to 3, the increase of the consumer surplus falls down, and the increase of producer surplus goes up, and the share of the increase of the producer surplus in the increase of the government total payment increases as well. This indicates that more and more government payment is contributed to the domestic producers. As the net imports increase, the decrease of the producer surplus from the ROW goes up and the net welfare loss in China increases too, so the subsidy will harm the producers from the ROW and generate more net welfare loss if China increases its net imports. As the subsidy increases from scenario 4 to 6, both consumer surplus and producer surplus increase more than that in scenario 1 to 3. The decrease of the producer surplus from the ROW is similar to that in scenario 1 to 3. The share of the increase of domestic producer surplus also goes up, but the increase of producer surplus is still smaller than the increase of the consumer surplus. Meanwhile, the increase of subsidy generates more net welfare loss in China. In scenario 1-3, when the net imports increase, the total surplus in China barely changes, but the consumer surplus falls and the producer surplus goes up. This indicates that the net imports can affect the distribution of welfare instead of the total welfare. In scenario 4-6, as the subsidy increases, the total surplus in China increases, but the increase of the consumer surplus is always larger than that of the producer surplus. Based on the results from scenario 1-6, import can adjust the distribution of welfare between consumers and producers. The increase in net imports lets farmers gain more from the subsidy. Increasing subsidy will increase both consumers and producers' welfare significantly. Both the increase of net imports and the increase of the subsidy increase the net welfare loss in China. The latter generate more net welfare loss than the former. But the proportion of the net welfare loss to the government's total pay shows the subsidy policy is more efficient than increasing imports which actually induce more welfare loss. The assumption is confirmed that both subsidy and net imports affect the welfare effect; the subsidy increases the total welfare and the net imports (the market structure) distribute the welfare, but the subsidy policy is more efficient when the net imports are less. China's government mainly wants to enhance farmers' welfare through the subsidy policy. How to adjust subsidy and net imports in order to make China's farmers gain more and avoid net welfare loss is an important and practical question faced by China's government. The results show that it is reasonable to concern with the wheat imports when increasing the subsidy, because the subsidy will increase the total welfare and imports will distribute more benefit to the producers, though the imports make the policy less efficient. That the total welfare increases but the farmers gain less will increase the income gap between rural and urban, because consumers always gain more than the producers and most farmers live in rural area. Some researchers have already noticed the results of the subsidy policy. For example, Zhao et al. (2014) mentioned that one of the unexpected results from China's Agricultural Subsidies Policy was that the income gap between China's urban and rural residents had increased steadily during a period when China's agricultural subsidies steadily increased. Wu and Hu (2007) suggested that the government implement positive import policies. Actually the value of ω determines the distribution of the welfare and both elastisities and shares affect the value of ω. It is assumed that the elastisities would not change in a short-run period so the analysis is based on the change of the imports. If the assumption is released, the results will be different.

7. Conclusions

This paper analyzes the incidence of the direct grain subsidy in China from 2009 to 2011. First I examine the essence of the direct grain subsidy and it is a kind of per-unit production subsidy; then use the EDM models to analyze the effect of the direct grain subsidy on prices, consumption, production, and welfare, and propose hypotheses based on the models; in the end, I verify the hypotheses by using the Chinese wheat industry as an example, and do quantitative analysis about the effect of the direct grain subsidy. The results are consistent with the previous study that the direct grain subsidy increases wheat production and farmers' welfare. In addition, the direct grain subsidy increases domestic consumption and consumer surplus, and decreases demand price, imports, and producer surplus in the ROW. What is important is that net imports affect the distribution of the welfare and make the subsidy policy less efficient.

The aim of the subsidy policy is to enhance production and farmers' income, and then achieve food self-sufficiency. According to previous studies, food security is a big challenge for China which has a large population and it will be necessary to import food for a while. This paper also confirms the importance of trade in re distributing welfare. Thus, China's government should pay attention to the international trade and adjust the imports to make the subsidy policy more efficient in the future.

FIGURES:

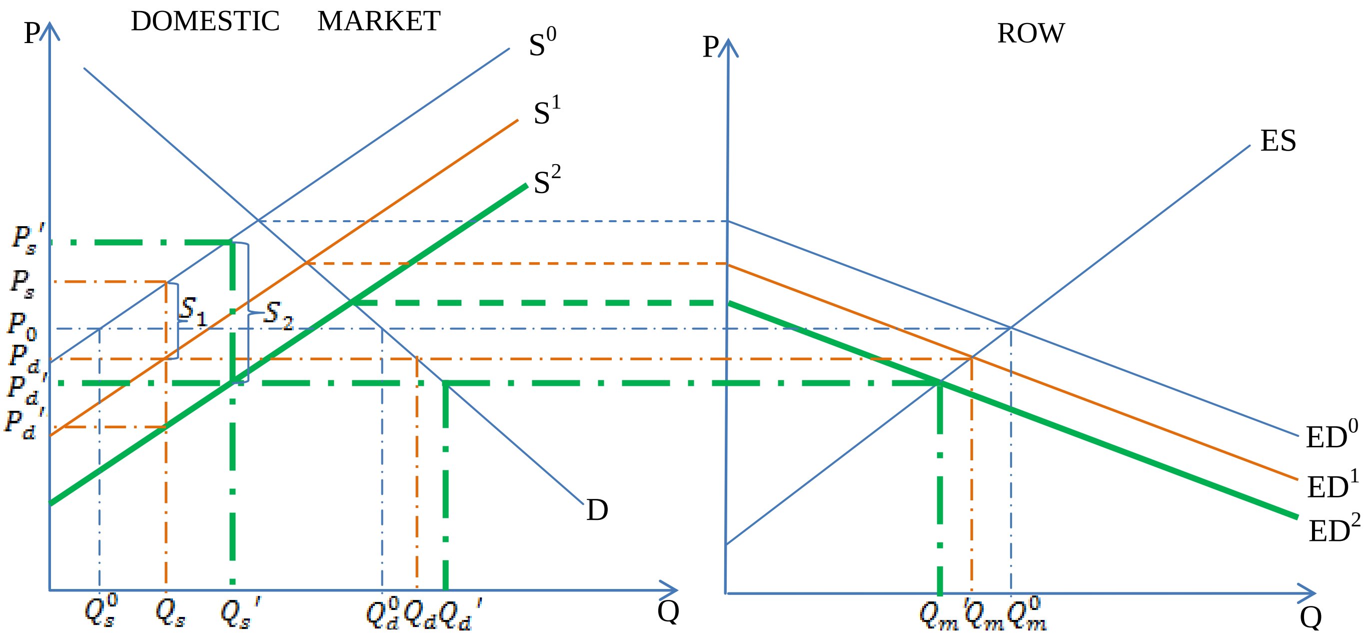

Figure 1.1 Graphical Analysis of the Effect of the Direct Grain Subsidy on Equilibriums

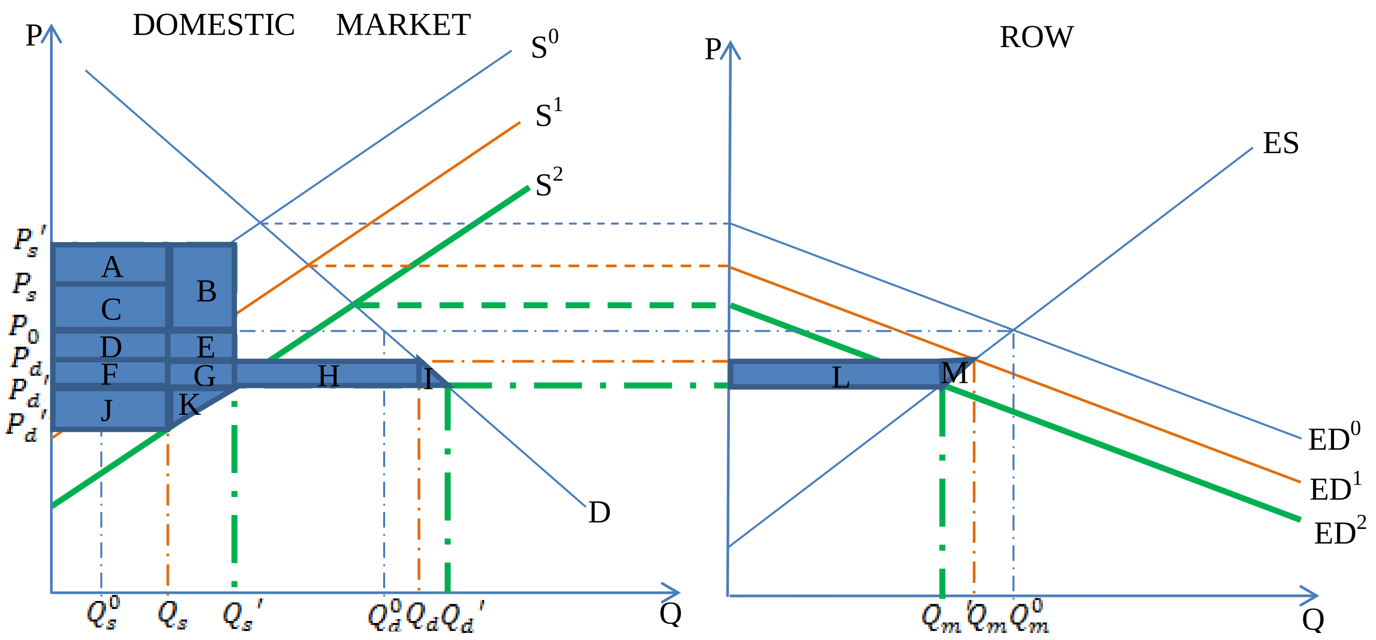

Figure 1.2 Graphical Analysis of the Welfare Effect of the Direct Grain Subsidy

TABLES:

Table 1.1 China's Wheat Demand, Supply and Net Imports (Millions of Metric Tons), 2009-2013

	2009	2010	2011	2012	2013
Total Consumption	107.0	110.5	122.5	125.0	123.5
Proportion in the world	16.35%	16.88%	17.58%	18.40%	17.57%
Total Production	115.1	115.2	117.4	121.0	121.7
Proportion in the world	16.75%	17.70%	16.87%	18.41%	17.04%
Net imports	0.5	0	1.9	2	6
Proportion in China	0.47%	0	1.55%	1.6%	4.86%

Source: United States Department of Agriculture, Foreign Agricultural Service, Grain: World Markets and Trade, May 2014.

Table 1.2 Contribution of the Direct Grain Subsidy to the Cost of the Wheat per Acre in China (USD), 2009-2011

	2009	2010	2011
Total Production	624.54	681.25	753.42
Total Cost	514.40	561.32	646.41
Land Cost	94.24	110.20	117.31
Subsidy (S_0)	53.57	51.52	59.09
Subsidy Ratio (subsidy/land cost)	56.84%	46.75%	50.37%
Land Cost Ratio	18.32%	19.63%	18.15%
Effective Subsidy Ratio	10.41%	9.18%	9.14%

Source: China rural statistical yearbook (2010).

Table 1.3 Parameter Definitions and Values, 2009-2011

Parameter	Definition	Value[a]		
		2009	2010	2011
η_d	China's domestic demand elasticity	-0.244	-0.244	-0.244
ε_d	China's domestic supply elasticity	0.320	0.320	0.320
ε_m	Supply elasticity in the ROW	2.822	2.822	2.822
k_d	China's domestic share of total consumption	99.53%	100.00%	98.45%
k_m	Imports' share of total consumption in China	0.47%	0.00%	1.55%
ω	The ratio between demand elasticity with respect to domestic production and supply elasticity	-0.81	-0.76	-0.91

[a]See text for detail.

Table 1.4 Reduced-form Elasticities, 2009-2011

	Values		
	2009	2010	2011
	$\tau_s = 10.41\%$	$\tau_s = 9.18\%$	$\tau_s = 9.14\%$
P_d^*	-0.06%	-0.05%	-0.05%
P_s^*	0.05%	0.04%	0.05%
Q_d^*	0.01%	0.01%	0.01%
Q_s^*	0.02%	0.01%	0.01%
Q_m^*	-0.17%	-0.16%	-0.14%

Table 1.5 Baseline Values (Dollars/Millions of Metric Tons), 2009-2011

Item	Definition	2009	2010	2011
P_d	Demand price per ton	276.26	295.99	310.76
P_s	Supply price per ton	325.79	355.37	393.02
S	Subsidy per ton	27.94	26.82	30.20
Q_d	Domestic consumption	107.00	110.50	122.50
Q_s	Domestic production	115.10	115.20	117.40
Q_m	Net imports from the ROW	0.50	0.00	1.90

Table 1.6 Welfare Effect of the Direct Grain Subsidy in China (Million USD), 2009-2011

		2009	2011	2011
ΔCS	Change of consumer surplus in China	18.07[a] (0.0611%)[b]	17.97 (0.0549%)	19.10 (0.0502%)
ΔPS_1	Change of producer surplus in China	17.53 (0.0551%)	15.73 (0.0461%)	18.41 (0.0505%)
ΔPS_2	Change of producer surplus from ROW	-0.08 (-0.0611%)	0.00	-0.30 (-0.0501%)
ΔTS	Change of total surplus in China	35.59	33.70	37.50
ΔG	Change of government payment	38.46	36.30	39.98
NWL	Net Welfare Loss in China	2.87	2.60	2.47

[a]Value Change

[b]Proportion Change

Table 1.7 Incidence of the Direct Grain Subsidy and Imports on Welfare

	Net imports increase			The direct grain subsidy increases		
	Scenario 1 (10%)	Scenario 2 (20%)	Scenario 3 (30%)	Scenario 4 (10%)	Scenario 5 (20%)	Scenario 6 (30%)
ω	-0.93	-0.94	-0.96	-0.91	-0.91	-0.91
ΔCS	18.94	18.78	18.62	21.11	23.15	25.21
ΔPS_1	18.56	18.71	18.86	20.56	22.77	25.05
ΔPS_2	-0.32	-0.35	-0.38	-0.33	-0.36	-0.39
ΔTS	37.50	37.49	37.49	41.67	45.92	50.26
ΔG	40.00	40.03	40.06	44.25	48.59	52.97
$\Delta CS/\Delta G$	47.33%	46.91%	46.49%	47.71%	47.64%	47.58%
$\Delta PS_1/\Delta G$	46.40%	46.74%	47.09%	46.45%	46.87%	47.29%
NWL	2.51	2.54	2.57	2.58	2.67	2.71
$NWL/\Delta G$	6.28%	6.35%	6.42%	5.83%	5.49%	5.12%

Appendix

Welfare Changes

The welfare change for Chinese consumers:

$$\Delta CS = (P_d - P_d') * Q_d + \frac{1}{2}(P_d - P_d') * (Q_d' - Q_d)$$

$$= (P_d - P_d') * \left[Q_d + \frac{1}{2} * (Q_d' - Q_d)\right]$$

$$= P_d * Q_d * \left(\frac{P_d - P_d'}{P_d}\right) * \left[1 + \frac{1}{2} * \left(\frac{Q_d' - Q_d}{Q_d}\right)\right]$$

$$= -P_d * Q_d * P_d{}^* * \left[1 + \frac{1}{2} * Q_d{}^*\right]$$

The welfare change for producers in the ROW:

$$\Delta PS_2 = -[(P_d - P_d') * Q_m' + \frac{1}{2}(P_d - P_d') * (Q_m - Q_m')]$$

$$= -(P_d - P_d') * [Q_m' - Q_m + Q_m + \frac{1}{2} * (Q_m - Q_m')]$$

$$= -P_d * Q_m * \left(\frac{P_d - P_d'}{P_d}\right) * [\frac{1}{2} * \frac{Q_m' - Q_m}{Q_m} + 1]$$

$$= P_d * Q_m * P_d{}^* * [\frac{1}{2} * Q_m{}^* + 1]$$

The change of Chinese government's payment:

$$\Delta G = Q_s' * (P_s' - P_d') - Q_s * (P_s - P_d)$$

$$= (Q_s' - Q_s + Q_s) * (P_s' - P_s - P_d' + P_d + P_s - P_d) - Q_s * (P_s - P_d)$$

$$= (Q_s' - Q_s + Q_s) * (P_s' - P_s) - (Q_s' - Q_s + Q_s) * (P_d' - P_d) + (Q_s' - Q_s) * (P_s - P_d)$$

$$= Q_s P_s \left(\frac{Q_s' - Q_s}{Q_s} + 1\right) * \left(\frac{P_s' - P_s}{P_s}\right) - Q_s P_d \left(\frac{Q_s' - Q_s}{Q_s} + 1\right) * \left(\frac{P_d' - P_d}{P_d}\right) + Q_s \left(\frac{Q_s' - Q_s}{Q_s}\right) * (P_s - P_d)$$

$$= Q_s P_s P_s^* (Q_s^* + 1) - Q_s P_d P_d^* (Q_s^* + 1) + Q_s Q_s^* * (P_s - P_d)$$

The welfare change for Chinese producers:

$$\Delta PS_1 = (P_d' - P_d'') * Q_s + \frac{1}{2}(P_d' - P_d'') * (Q_s' - Q_s)$$

$$= (P_d' - P_d'') * \left[Q_s + \frac{1}{2} * (Q_s' - Q_s)\right]$$

$$= -(P_d'' - P_d') * \left[Q_s + \frac{1}{2} * (Q_s' - Q_s)\right]$$

$$= -(P_d'' - P_d + P_d - P_d') * \left[Q_s + \frac{1}{2} * (Q_s' - Q_s)\right]$$

$$= -P_d * Q_s * \left(\frac{P_d'' - P_d}{P_d} + \frac{P_d - P_d'}{P_d}\right) * \left[1 + \frac{1}{2} * \left(\frac{Q_s' - Q_s}{Q_s}\right)\right]$$

$$= -P_d * Q_s * (Vs - P_d{}^*) * \left[1 + \frac{1}{2} * Q_s{}^*\right]$$

Here, $Vs = \frac{P_d'' - P_d}{P_d}$ and it is the vertical shift of the domestic supply.

Because$Q_s^* = \varepsilon_d \mathrm{P}_s^* = \varepsilon_d[(1 - \tau_s)P_d^* + \tau_s S^*]$, $\mathrm{P}_d^* = \frac{Q_s{}^*}{\varepsilon_d(1-\tau_s)} - \frac{\tau_s}{(1-\tau_s)} S^*$. Holding Q_s constant, vertical shift is$-\frac{\tau_s}{(1-\tau_s)} S^*$.

Then the above equation can be expressed more clearly as:

$$\Delta \mathrm{PS}_1 = -P_d * Q_s * \left(-\frac{\tau_s}{(1 - \tau_s)} S^* - P_d{}^*\right) * \left[1 + \frac{1}{2} * Q_s{}^*\right]$$

Chapter 2. The Effects of Mongolia's Booming Mining Industry on its Agricultural Sector: A Test of the Dutch Disease Hypothesis

1. Introduction

As mining grows in Mongolia, its status as a transitional economy depends on continuing to attract foreign investment. According to World Bank figures, Mongolia has attracted over $14 billion of foreign direct investment (FDI) between 1990 and 2013, of which 73% or $10 billion poured into the mining industry.[5] Inward investment is essential for Mongolia to exploit its extensive mineral deposits. Mongolia is a resource-rich country and also a small open economy which relies on international trade. Between 2009 and 2014 Mongolia's exports increased at an annualized rate of 32% from $1.55 billion to $6.14 billion. Copper ore led its exports at 42% of total, followed by coal briquettes (13.7%), and gold (13.4%). Its top export destinations in 2014 were China (80% of total), Switzerland (7.3%), the United Kingdom (6.7%), Italy (0.94%), and Russia (0.90%). In 2014 Mongolia ran a trade surplus of $1.4 billion, it first surplus since 2006 and the largest on record.[6] Meanwhile, Mongolia's real GNP between 2009 and 2013 increased by 67%, and the real value of its currency (the tugrik or MNT) increased against major world currencies by between 12% and 37% (Table 2.1). A stronger domestic currency makes a country's exports more expensive in world markets and its imports less expensive. Thus, trade-sensitive sectors such as agriculture are apt to be harmed. Agriculture accounts for approximately 42% of Mongolia's labor force and 20% of its GNP (Markowitz 2013). Mongolia is the world's second largest exporter of cashmere,

[5] In this paper, all values are expressed in U.S. dollars.

[6] The statistics in this and the preceding two sentence were obtained from http://atlas.media.mit.edu/en/profile/country/mng/ (accessed 8 June 2016).

and exports significant quantities of its livestock and animal products, including wool and hides. It relies on imports for a significant share of its domestic consumption of rice and fresh fruits and vegetables.[7] At issue is whether the development of the mining sector and associated currency strengthening has had a negative effect on the agricultural sector, a phenomenon known as "Dutch disease."

The term "Dutch disease" was coined in 1977 by *The Economist* magazine to describe the decline of the manufacturing sector in the Netherlands after the discovery of a large natural gas field in 1959. In economics, the Dutch disease is the apparent relationship between the increase in the economic development of natural resources and a decline in the manufacturing sector (or agriculture). The mechanism is that an increase in revenues from natural resources (or inflows of foreign aid) will make a given nation's currency stronger compared to that of other nations (manifest in an exchange rate), resulting in the nation's other exports becoming more expensive for other countries to buy. While it most often refers to natural resource discovery, it can also refer to "any development that results in a large inflow of foreign currency, including a sharp surge in natural resource prices, foreign assistance, and foreign direct investment" (Ebrahim-zadeh 2003).

The classic economic model describing Dutch Disease was developed by Corden and Neary (1982). In the model, there is a non-tradable sector (which includes services) and two tradable sectors: the booming sector, and the lagging (or non-booming) tradable sector. The booming sector is usually the extraction of natural resources such as oil, natural gas, copper or gold. The lagging sector is usually manufacturing or agriculture. A

[7] For more details on Mongolia's agricultural sector, see Markowitz (2013) and http://www.economywatch.com/world_economy/mongolia/export-import.html (accessed 8 June 2016).

resource boom affects this economy in two ways. In the "resource movement effect," the resource boom increases the demand for labor, which causes production to shift toward the booming sector, away from the lagging sector. This shift in labor from the lagging sector to the booming sector is called "direct-deindustrialization." However, this effect can be negligible, since the hydrocarbon and mineral sectors tend to employ few people. The "spending effect" occurs as a result of the extra revenue brought in by the resource boom. It increases demand for labor in the non-tradable sector (services), at the expense of the lagging sector. This shift from the lagging sector to the non-tradable sector is called "indirect-deindustrialization." The increased demand for non-traded goods increases their price. However, prices in the traded good sector are set internationally, so they cannot change. This amounts to an increase in the real exchange rate.

Before asking if Dutch Disease (hereafter DD) is bad, we need to know if DD exists in a certain economy. Evidence from the literature is mixed. Apergis et al. (2014) found a negative relationship between oil rents and agriculture value-added in the long run. Dülger et al. (2013) examined whether Russia suffered from DD by investigating the real appreciation of the Russian ruble and the relative de-industrialization in the post-Soviet Union era using a cointegration framework. They found the Russian economy exhibited some typical symptoms of DD. Pegg (2010) examined the economy of Botswana and found it did not suffer from DD though it did suffer from many of its symptoms.

The purpose of this research is to determine whether DD is applicable to Mongolia. A Keynesian-style equilibrium displacement model (EDM) is specified to determine the effect of FDI-induced currency strengthening on Mongolia's agricultural sector from a theoretical perspective. The necessary conditions for the DD hypothesis to hold are tested by estimating the relationship between exchange rate, FDI and GNP using co-integration techniques. Having determined that the necessary conditions hold, the hypothesis itself is tested by simulating the EDM using Monte Carlo techniques to derive 90% confidence intervals for the relevant reduced-form elasticities. Results suggest the FDI-led mining boom has no significant effect on Mongolia's agricultural sector. Although the DD hypothesis is rejected, model simulations suggest the mechanism identified by the DD hypothesis, namely the negative effect of currency strengthening on a lagging sector induced by growth in a booming sector, is important. Specifically, in the absence of currency strengthening model simulations suggest the agricultural sector would have grown in response to increased FDI. The induced currency strengthening converted a positive relationship to no relationship.

The next section presents the theoretical framework for the analysis. This is followed by an empirical section in which an augmented autoregressive distributed lag (ARDL) model is used to estimate the effect of FDI and GDP on the exchange rate. Results from the econometric analysis are then used in stochastic simulations of the economic model to compute reduced-form elasticities for FDI and Keynesian multipliers. A final section summarizes our key findings.

2. Theoretical Framework

2.1. Structural Model

The structural model used for this analysis follows the one used by Glytsos (2005) to study the effects of migrant remittances on the economies of five Mediterranean countries. This model was selected because, like the countries studied by Glytsos, Mongolia is a small open economy. The channels through which foreign direct investment affect the domestic economy are similar to the channels through which migrant remittances affect the economy. The model is simple, yet sufficiently general to permit analysis of how an FDI-induced change in one sector of the economy spills over into other sectors. The empirical estimates of model parameters obtained by Glytsos can be used to gain quantitative insight into the DD hypothesis as it might apply to Mongolia.

The model in static general-function form consists of seven equations

(1) $$C = C(Y) \qquad \left(\frac{\partial C}{\partial Y} > 0\right)$$

(2) $$MN = MN(Y, \bar{K}_{MN}, \overline{FDI}, e)$$

$$\left(\frac{\partial MN}{\partial Y} > 0, \frac{\partial MN}{\partial \bar{K}_{MN}} < 0, \frac{\partial MN}{\partial \overline{FDI}} > 0, \frac{\partial MN}{\partial e} < 0\right)$$

(3) $$AG = AG(Y, \bar{K}_{AG}, e) \qquad \left(\frac{\partial AG}{\partial Y} > 0, \frac{\partial AG}{\partial \bar{K}_{AG}} < 0, \frac{\partial AG}{\partial e} < 0\right)$$

(4) $$OS = OS(Y, \bar{K}_{OS}) \qquad \left(\frac{\partial OS}{\partial Y} > 0, \frac{\partial OS}{\partial \bar{K}_{OS}} < 0\right)$$

(5) $$M = M(Y, e) \qquad \left(\frac{\partial M}{\partial Y} > 0, \frac{\partial M}{\partial e} > 0\right)$$

(6) $$e = e(Y, \overline{FDI}) \qquad \left(\frac{\partial e}{\partial Y} > 0, \frac{\partial e}{\partial \overline{FDI}} > 0\right)$$

(7) $$Y = C + MN + AG + OS + M + \bar{G} + \overline{FDI}$$

where C is personal consumption expenditures; Y is national income; MN, AG, and OS are the levels of investment in the mining, agricultural, and other sectors, respectively; M is the value of net imports; e is the exchange rate (foreign currency unit per domestic currency unit); $\bar{K}_{MN}$, $\bar{K}_{AG}$, and $\bar{K}_{OS}$ are the levels of capital stock in the mining, agricultural, and other sectors, respectively; $\bar{G}$ is government expenditures; and $\overline{FDI}$ is foreign direct investment. The model consists of seven endogenous variables (C, MN, AG, OS, M, e, and Y) and five exogenous variables ($\bar{K}_{MN}$, $\bar{K}_{AG}$, $\bar{K}_{OS}$, $\bar{G}$, and $\overline{FDI}$). The model is Keynesian in form. The only substantive difference between the present model and the one specified by Glytsos is the inclusion of exchange rate as an additional endogenous variable. This inclusion is done, of course, to test the DD hypothesis.

Glytsos in his analysis assumes consumption, investment and imports are positively related to income, and investment is negatively related to capital stock. He also assumes exports and migrant remittances are exogenous. We adopt the same assumptions (noting that in our model FDI is the focus of analysis rather than remittances). That FDI is exogenous receives empirical support from Davaakhuu et al. (2014, p. 447). In that study, a Hausman test conducted on a model of Mongolia's export intensity failed to detect endogeneity in the FDI variable. Domestic currency strengthening, i.e, an increase in e, is assumed to have a positive effect on imports, a negative effect on the mining and agricultural sectors, and no effect on other sectors. The implicit assumption here is that the mining and agricultural sectors of Mongolia's economy are the ones most exposed to international competition, and thus the ones most likely to be affected by changes in the value of Mongolia's currency. Domestic currency strengthening makes imports cheaper to domestic consumers, and exports more expensive to foreign buyers. An isolated increase in foreign direct investment is assumed to enlarge the size of the mining sector, and to have no *direct* effect on the size of the other sectors of the economy, including agriculture. (To the extent an increase in FDI increases income, there will be indirect effects.) The implicit assumption here is that inflows of foreign capital are directed primarily if not exclusively at the mining sector.

We assume an isolated increase in income or FDI will cause the domestic currency to strengthen. The latter is consistent with the standard prediction from the DD model. Empirical evidence, however, is not fully consistent with this prediction (e.g., Fielding and Gibson 2013). Consequently, in the econometric analysis presented later we test this assumption.

2.2. Comparative Statics

Given the foregoing structure, what hypotheses can be deduced about the effects of a change in FDI directed at the mining sector on the agricultural sector? The question may be addressed by performing comparative static analysis. For this purpose, we first write the model in proportionate change form to yield:

(8) $C^* = \alpha_Y Y^*$ $(\alpha_Y > 0)$

(9) $MN^* = \beta_Y Y^* + \beta_K \bar{K}^*_{MN} + \beta_{FDI}\overline{FDI}^* + \beta_e e^*$

$(\beta_Y > 0, \beta_K < 0, \beta_{FDI} > 0, \beta_e < 0)$

(10) $AG^* = \gamma_Y Y^* + \gamma_K \bar{K}^*_{AG} + \gamma_e e^*$ $(\gamma_Y > 0, \gamma_K < 0, \gamma_e < 0)$

(11) $OS^* = \delta_Y Y^* + \delta_K \bar{K}^*_{OS}$ $(\delta_Y > 0, \delta_K < 0)$

(12) $M^* = \theta_Y Y^* + \theta_e e^*$ $(\theta_Y > 0,\ \theta_e > 0)$

(13) $e^* = \varphi_Y Y^* + \varphi_{FDI}\overline{FDI}^*$ $(\varphi_Y > 0, \varphi_{FDI} > 0)$

(14) $Y^* = s_C C^* + s_{MN} MN^* + s_{AG} AG^* + s_{OS} OS^* - s_M M^* + s_G \bar{G}^* + s_{FDI}\overline{FDI}^*.$

The asterisk (*) indicates proportionate change (e.g., $C^* = dC/C$ is the proportionate change in personal consumption expenditures); the Greek symbols are structural elasticities; and $s_i = i/Y > 0$ $(i = C,\ MN, AG, OS,\ M,\ \bar{G},\ \overline{FDI}\ )$ are income shares that sum to one. The reduced form is obtained by solving equations (8) – (14) simultaneously for the endogenous variables in terms of the exogenous variables. To determine how the effects of increased FDI on the economy are affected by currency strengthening, in addition to the full reduced form, we derive a quasi-reduced form that treats exchange rate as temporarily exogenous.

The relevant equations, derived in appendix A, are:

(15) $$AG^* = \overbrace{\left(\frac{\gamma_Y(s_{MN}\beta_{FDI} + s_{FDI})}{D}\right)}^{A>0}\overline{FDI}^* + \overbrace{\left(\frac{\gamma_Y(s_{MN}\beta_e + s_{AG}\gamma_e - s_M\theta_e) + D\gamma_e}{D}\right)}^{B<0}\bar{e}^*$$

(16) $$e^* = \overbrace{\left(\frac{\varphi_Y(s_{MN}\beta_{FDI} + s_{FDI}) + D\varphi_{FDI}}{D - \varphi_Y(s_{MN}\beta_e + s_{AG}\gamma_e - s_M\theta_e)}\right)}^{C>0}\overline{FDI}^*$$

(17) $$AG^* = (A + B \cdot C)\overline{FDI}^*$$

where $D^{-1} = 1/\left(1 - \frac{\partial C}{\partial Y} - \frac{\partial MN}{\partial Y} - \frac{\partial AG}{\partial Y} - \frac{\partial OS}{\partial Y} + \frac{\partial M}{\partial Y}\right) > 0$ is the Keynesian multiplier.[8] Equation (15) is a quasi-reduced form. Its coefficients tell the sensitivity of the agricultural sector to isolated one percent changes in FDI and the exchange rate assuming the exchange rate is exogenous, i.e., unaffected by changes in FDI and Y. Equations (16) and (17) are full reduced forms. Their coefficients tell the sensitivity of exchange rate and the agricultural sector to an isolated one percent change in FDI assuming the exchange rate is endogenous. If the exchange rate is exogenous, i.e., unresponsive to changes in FDI or Y, the model yields the hypothesis $\frac{AG^*}{FDI^*} > 0$. In this instance, an increase in mining-based FDI is expected to cause the agricultural sector to increase in size (positive spillover). If, on the other hand, the exchange rate is endogenous, i.e., responsive to changes in FDI or Y, the model lacks predictive content. That is, the spillover effect of a change in mining-based FDI on the agricultural sector may be positive, negative, or nil depending on the relative magnitudes of the coefficients $A > 0$ and $B \cdot C < 0$ in equations (15) and (16). In terms of the DD hypothesis, a necessary condition for the hypothesis to hold is that $C \neq 0$. This, in turn, requires that the φ parameters in equation (13) be non-zero, a hypothesis that we test in the next section.

3. Empirical Analysis

3.1. Model Specification

---

[8]The multiplier is derived from the quasi reduced-form elasticity $\frac{Y^*}{G^*} = \frac{s_G}{1 - s_C\alpha_Y - s_{MN}\beta_Y - s_{AG}\gamma_Y - s_{OS}\delta_Y + s_M\theta_Y}$ (see appendix A). By definition $s_C\alpha_Y = \frac{C}{Y}\left(\frac{\partial C}{\partial Y}\frac{Y}{C}\right) = \frac{\partial C}{\partial Y} = MPC$. Applying the same algebra to the remaining terms in the numerator of the elasticity yields $\frac{Y^*}{G^*} = \frac{s_G}{1 - \frac{\partial C}{\partial Y} - \frac{\partial MN}{\partial Y} - \frac{\partial AG}{\partial Y} - \frac{\partial OS}{\partial Y} + \frac{\partial M}{\partial Y}}$. Dividing through by s_G gives the multiplier, namely $\frac{\partial Y}{\partial G} = \frac{1}{1 - \frac{\partial C}{\partial Y} - \frac{\partial MN}{\partial Y} - \frac{\partial AG}{\partial Y} - \frac{\partial OS}{\partial Y} + \frac{\partial M}{\partial Y}} = D^{-1}$. A positive multiplier implies $D > 0$.

The φ parameters are estimated using the autoregressive distributed lag (ARDL) approach to cointegration developed by Pesaran *et al*. (2001). A key advantage of this approach is that it can be applied irrespective of whether the explanatory variables are *I*(0) or *I*(1), and thus avoids pre-testing problems associated with standard cointegration techniques (e.g., Engel and Granger, 1987; Johansen, 1995) that require the classification of variables into stationary or non-stationary. The ARDL approach appears to perform better than other cointegration tests, even in small samples (Pesaran and Shin 1999), an important consideration in the present analysis as our sample is limited to 21 (annual) observations.

Cuddington and Dagher (2015, p. 191) recommend that to avoid an overly restrictive specification, each explanatory variable in an ARDL should enter with at least two time subscripts (the number of lags for the dependent variable does not matter). Following this recommendation, our basic specification is an ARDL(1,2,2) defined as follows:

(18) $e_t = a_0 + a_{e1} e_{t-1} + a_{y0} y_t + a_{y1} y_{t-1} + a_{y2} y_{t-2} + a_{f0} f_t + a_{f1} f_{t-1} + a_{f2} f_{t-2} + \varepsilon_t$

where e_t is the natural log of the real exchange rate in year t; y_t is the natural log of the real national income (GDP) in year t; f_t is the natural log of real FDI in year t; and ε_t is a random disturbance term. The φ parameters (long-run elasticities) are computed from model parameters as follows:

(18a) $$\varphi_Y = \frac{a_{y0} + a_{y1} + a_{y2}}{1 - a_{e1}}$$

(18b) $$\varphi_{FDI} = \frac{a_{f0} + a_{f1} + a_{f2}}{1 - a_{e1}}.$$

To obtain direct estimates of these parameters and their respective standard errors, we exploit the fact that every ADL model can be expressed alternatively as an error correction model, or ECM. The ECM isomorphic to equation (18) is

(19)

$$\Delta e_t = a_0 + \lambda(\varphi_Y y_{t-1} + \varphi_{FDI} f_{t-1} - e_{t-1}) + a_{y0}\Delta y_t - a_{y2}\Delta y_{t-1} + a_{f0}\Delta f_t - a_{f2}\Delta f_{t-1} + \varepsilon_t$$

where $\lambda = (1 - a_{e1})$ is a speed-of-adjustment parameter.[9] For example, if $\lambda = 0.5$ this means 50% of the total adjustment to the new equilibrium occurs in the first year. Interpreting a_{y0} and a_{f0} as short-run elasticities, the closer λ is to 1 the closer the long-run elasticities given in equations (18a) and (18b) are to their short-run counterparts. The φ parameters and their standard errors can be estimated directly from equation (19) using non-linear least squares.

3.2. Restricted Forms

The ECM nests several specifications of empirical interest. Labeling equation (19) as Model A, these are listed below as Models B, C, and D.

<u>Model B (Delayed Response Model or DRM)</u>

(20)

$$\Delta e_t = a_0 + \lambda(\varphi_Y y_{t-1} + \varphi_{FDI} f_{t-1} - e_{t-1}) - a_{y2}\Delta y_{t-1} - a_{f2}\Delta f_{t-1} + \varepsilon_{Bt}$$

(20a) $\varphi_Y = \frac{a_{y1}+a_{y2}}{1-a_{e1}}$

(20b) $\varphi_{FDI} = \frac{a_{f1}+a_{f2}}{1-a_{e1}}$.

<u>Model C (Partial Adjustment Model or PAM)</u>

(21) $\Delta e_t = a_0 + \lambda(\varphi_Y y_t + \varphi_{FDI} f_t - e_{t-1}) + \varepsilon_{Ct}$

(21a) $\varphi_Y = \frac{a_{y0}}{1-a_{e1}}$

(21b) $\varphi_{FDI} = \frac{a_{f0}}{1-a_{e1}}$.

---

[9] The algebraic steps to show the equivalence between an ADL and ECM are provided in Appendix I of Cuddington and Dagher's (2015) paper.

Model D (Static First-Difference Model or SFD)

(22) $$\Delta e_t = a_0 + a_{y0}\Delta y_t + a_{f0}\Delta f_t + \varepsilon_{Dt}$$

(22a) $\varphi_Y = a_{y0}$

(22b) $\varphi_{FDI} = a_{f0}$.

Model B imposes the restriction $a_{y0} = a_{f0} = 0$, which implies it takes one year before the real exchange rate begins to respond to changes in real GNP and FDI. Model C imposes the restriction that only contemporaneous responses matter in the determination of the long-run response, i.e., $a_{y1} = a_{y2} = a_{f1} = a_{f2} = 0$. Model D imposes the restriction that adjustments in the real exchange rate to changes in real GDP and FDI are completed in the same year in which the changes occur, i.e., $a_{y1} = a_{y2} = a_{f1} = a_{f2} = a_{e1} = 0$. Each of these restrictions can be tested using a standard *F*-statistic provide the disturbance term ε_t in equation (19) is well behaved, an issue we address later.

3.3. Data

The data used to estimate the models are given in table 2.1. All variables are in real terms. The deflators are defined in appendix table 2.1, as are the sources for all the data used in this study. Real FDI increased at triple digit rates over the last 15 years of the sample period, while real GNP increased at double digit rates. The Mongolian currency mostly increased in value over this period when measured against major world currencies. The one exception is against the Russian ruble between 1999 and 2008, and against the euro between 1999 and 2003. Over the last five years of our sample FDI as a share of GNP skyrocketed from 12% in 2009 to 53% in 2011 before declining to 18% in 2013. Mongolia's currency increased in value over this period by between 10% and 37%, with the smallest increase corresponding to the ruble and the largest with the euro.

That the domestic currency strengthened *pari passu* with the increase in FDI is important because without such an association, the DD hypothesis would be mute.

The time plots of the six variables are shown in figures 2.1 and 2.2. Figure 2.1 shows the deviations from mean real exchange rates. All the exchange rates moved up and down significantly from the mean value. The exchange rates of USD/MNT, EURO/MNT and CNY/MNT show that the Mongolian currency strengthened in the recent years. But the exchange rate of RUB/MNT shows that the Mongolian currency became weaker.

In early 21th century, the change of RUB/MNT was more significant than other exchange rates. Figure 2.2 indicates that the real GDP shows a steadily rising trend while FDI increased up to 2011 and decreased afterwards. The graphs suggest a linear trend should be included in the empirical model, to which we now turn.

3.4. Estimation Procedure

Although the ARDL is applicable irrespective of whether the variables are *I*(0) or *I*(1), none of the variables should be *I*(2) as then calculated *F*-statistics are invalid. Thus, the first step in the estimation process is to determine whether any of the variables in Table 2.1 (when converted to logarithms) is *I*(2). For this purpose, we use the Augmented Dickey-Fuller test with trend and no lag. The hypothesis that the six variables included in the analysis either are *I*(0) or *I*(1) cannot be rejected at $p \leq 0.05$ level (Table 2.2).

The next step involves determining whether there is a long-run relationship among the variables. For his purpose, we used the bounds test developed by Pesaran *et al*. (2001). This entails testing whether the lagged level variables in equation (19) are jointly significant using an *F*-statistic. Pesaran *et al*. (2001) provide two sets of asymptotic critical values for the *F*-test. One set assumes all variables are *I*(0); the other assumes they are all *I*(1). The null hypothesis of no relationship is $H_0: \lambda = \varphi_Y = \varphi_{FDI} = 0$

against $H_1: \lambda \neq 0, \varphi_Y \neq 0, \varphi_{FDI} \neq 0$. The null is rejected if the computed *F* exceeds the upper-bound critical value and is not rejected if the computed *F* is below the lower bound. If the computed *F*-statistic is between the upper and lower bounds the test is inconclusive.

Because test results are sensitive to lag length it is important that the lag order be sufficiently generous to mitigate serial correlation, but not so generous as to cause the model to be unduly over-parameterized, particularly when degrees of freedom are limited (Pesaran *et al*., 2001, p. 308). Thus, prior to applying the bounds test, we tested for first-order serial correlation using three alternative tests: the Lagrange Multiplier (LM) test, the correlogram *Q*-statistic, and the correlogram Squared Residuals test. All three tests indicate the null hypothesis of no serial correlation cannot be rejected at the $p \leq 0.05$ level (Table 2.3). The one exception is for the RUB/MNT based on the Squared Residuals test. However, because this test result is inconsistent with the other two, and further testing with higher lag orders failed to confirm serial correlation, we treat it as a false positive. We also tested for normality of the disturbance term using the Jarque-Bera statistic. The null hypothesis of normality could not be rejected in any of the equations at any reasonable probability level.[10] These results, taken together, suggest an ARDL(1,2,2) model is sufficient to capture the data generating process for all four exchange rates.

Turning to the test for cointegration, the computed *F*-statistics for USD/MNT of 6.72 and for CNY/MNT of 16.06 are sufficiently large to reject the null hypothesis of no cointegration at the $p \leq 0.05$ level (Table 2.3).[11] For these exchange rates, it can be

---

[10] The *p*-values for the Jarque-Bera test corresponding to USD/MNT, CNY/MNT, EUR/MNT, and RUB/MNT are 0.917, 0.752, 0.996, and 0.971, respectively.

[11] The critical values for the tests are taken from the appendix table in Narayan's (2005) paper for a sample size of 30. The critical values in Pesaran et al.'s (2001) paper are not

inferred that e_t, y_t, and f_t share a long-run relationship with low probability of a Type I error. Conversely, the computed *F*-statistics for EUR/MNT of 2.31 and for RUB/MNT of 2.23 are too small to reject the null even at the $p \leq 0.10$ level. Thus, the real exchange rates for the euro and ruble appear to be unrelated movements in real GNP or FDI, at least from a long run perspective.[12] Given the apparent lack of a long-run relationship, the EUR/MNT and RUB/MNT relations are removed from further analysis.

With the existence of a level relationship established for USD/MNT and CNY/MNT, the ARDL model can be used to estimate the long-run elasticities φ_Y and φ_{FDI} and the error correction term λ. OLS estimation will yield consistent estimates of the short-run elasticities a_{y0} and a_{f0} and super-consistent estimates of φ_Y and φ_{FDI} provided the long-run relationship linking the variables is unique (Pesaran and Shin 1999; Cuddington and Dagher, 2015, p. 197). Moreover, valid inferences can be made using standard *t* and *F* distributions provided the variables are weakly exogenous (Pesaran and Shin 1999, pp. 381-389), a maintained hypotheses.[13]

---

used because they are based on a sample size of 1,000 and thus are apt to result in over-rejection of the null in the present study.

[12] As noted by Cuddington and Dagher (2015, p. 197), the absence of a long-run relationship among variables does not preclude a short-run relationship. If the latter is important, one can still estimate the ADL and just focus on the short-run elasticities.

[13] In principle, weak exogeneity could be tested for by estimating a vector error correction model (VECM) and testing whether the coefficient of the error correction term in the equations for y_t and f_t is zero. In our study, the degrees of freedom are too limited to have much confidence in such a test. Since our structural model posits FDI is exogenous, the issue boils down to whether GNP can be taken to be weakly exogenous.

A final consideration is whether any of the restricted forms given by Models B, C and D are statistically equivalent to Model A, thus permitting a more parsimonious specification. For this purpose, *F*-tests were conducted to determine whether the zero restrictions implied by Models B, C and D are compatible with data. Results indicate that for USD/MNT all of the restricted forms are rejected at the $p \leq 0.05$ level (Table 2.4). For CNY/MNT the delayed adjustment model (Model B) is rejected at the $p \leq 0.05$ level, while the partial adjustment (Model C) and the static first-difference (Model D) models are not. These results suggest dynamics are less important in explaining movements in CNY/MNT than in USD/MNT. Given the results, estimation proceeds by applying OLS to Model A for the USD/MNT relation, and to Models C and D for the CNY/MNT relation. The estimated relations include a trend term to test whether exchange rates are affected by technical change or other unmeasured factors that change gradually over time.

3.5. Estimation Results

The static specification (Model D) shows poor explanatory power (Table 2.5) and thus attention is restricted to the dynamic specifications (Models A and C). The dynamic specifications appear adequate in that most of the estimated parameters have the correct sign and are significant. The R^2 for Model A is 0.84 and for Model C is 0.92. This suggests a major portion of the variation in the real exchange rates for USD/MNT and CNY/MNT can be "explained" by variations in real GNP, real IDF, and trend (when all variables except trend are expressed in natural logs). All estimation results are obtained using EViews (version 9).

If not, the estimated short-run elasticity a_{y0} will suffer from simultaneous-equation bias. However, the long-run elasticity φ_Y should be free from such bias, as the variable connected with this parameter enters the ECM in lagged form (see equation (19)).

3.51. GNP Effect

The estimated value for φ_Y in the USD/MNT relation is 0.435 (t-ratio = 5.71) and in the CNY/MNT relation is 0.253 (t-ratio = 8.36). An isolated 1% increase in real GNP is associated with a 0.44% increase in the real value of Mongolia's tugrik against the U.S. dollar and a 0.25% increase in the real value of the tugrik against the Chinese yuan. These estimates indicate long-run responses. The short-run (one year) responses are given by the estimates for a_{y0}. The estimated value for a_{y0} in the USD/MNT relation is -0.071 (t-ratio = -0.74) and in the CNY/MNT relation is 0.470 (t-ratio = 6.42).[14] An isolated increase in real GNP has no effect on the USD/MNT real exchange rate in the short-run, while the effect on the CNY/MNT rate is relatively pronounced. Overall, the hypothesis that economic growth in Mongolia causes Mongolia's currency to strengthen is strongly supported by the data, at least with respect to the U.S. dollar and the Chinese yuan.

3.52. FDI Effect

The estimated value for φ_{FDI} in the USD/MNT relation is 0.380 (t-ratio = 4.43) and in the CNY/MNT relation is 0.015 (t-ratio = 0.87). An isolated 1% increase in real FDI is associated with a 0.38% increase in the value of Mongolia's tugrik against the U.S. dollar in the long run, and a 0.02% increase in the value of the tugrik against China's yuan. The latter estimate, however, is not statistically significant. The corresponding short-run effects (the estimated values for a_{f0}) are 0.173 (t-ratio = 3.73) for the USD/MNT rate and

---

[14] Short-run elasticities from the partial-adjustment model (Model C) are obtained by multiplying the long-run elasticities by the adjustment parameter λ. The short-run elasticity for GNP, for example, is computed as $\hat{a}_{y0} = \hat{\varphi}_Y \cdot \hat{\lambda}$. The standard error of the short-run elasticity is obtained using the delta method.

0.028 (*t*-ratio = 0.88) for the CNY/MNT. An isolated increase in real FDI increases the USD/MNT real exchange rate in the short-run, but has no effect on the CNY/MNT rate. Overall, the hypothesis that real inflows of foreign direct investment causes Mongolia's currency to strengthen is strongly supported by the data in the case of the U.S. dollar. The hypothesis receives little support, however, in the case of the Chinese yuan.

3.53. Trend Effect

The estimated coefficients of trend term in the USD/MNT relation is -0.131 (*t*-ratio = -3.50) and in the CNY/MNT relation is -0.028 (*t*-ratio = -2.82). In the absence of changes in real GNP and FDI, the tuhgrit would depreciate in real terms at an average annual rate of 13.1% against the U.S. dollar and 2.8% against the Chinese yuan. The estimates suggest the U.S. dollar plays a more important role in Mongolia's economy than the yuan. They also suggest technical change or other unmeasured factors that change gradually over time could easily mask or even offset the effects of economic growth or increases in foreign direct investment on Mongolia's exchange rate.

3.54. Error Correction Term

The estimated value of λ in the USD/MNT relation is 1.11 (*t*-ratio = 4.46) and in the CNY/MNT relation is 1.85 (*t*-ratio = 12.7). The large *t*-ratios reinforce the conclusion that a long-run equilibrium relationship exists among the variables (Kremers et al. 1992; Banerjee *et al*. 1998). Specifically, the upper-bound critical *t* for the bounds test at the 2.5% and 1% levels of statistical significance respectively are 4.20 and 4.53 (Pesaran et al., 2001, Table CII(v), p. 304). Thus, the null hypothesis that no long-run relationship exists can be rejected at least the $p \leq 0.025$ level. That the point estimates of the error-correction term exceed 1 suggests overshooting in the adjustment of real exchange rates to changes in real GNP or FDI. Overall, it would appear that Mongolia's exchange rates are more responsive to economic forces in the short run than in the long run. This inference is particularly valid for the yuan as $\hat{\lambda} \in [1.54, 2.17]$ with 95% certainty.

4. Simulation

The empirical results indicate FDI has a statistically significant effect on the USD/MNT exchange rate when both variables are expressed in real terms. But is the relationship empirically significant from the standpoint of the DD hypothesis? In particular, what are the spillover effects on the agricultural sector of an increase in the value of Mongolia's currency in relation to the U.S. dollar associated with an increase in FDI directed primarily at the mining sector? Is the effect negative, as predicted by the DD hypothesis? To address the question, we simulated the structural model (equations (8) – (14)) using a combination of observed, estimated, and "best-bet" parameter values. The simulations are performed assuming the exchange rate is, alternatively, exogenous and endogenous. A comparison of the reduced-form elasticities for FDI under each scenario provides a basis for assessing the validity of the DD hypothesis.

4.1. Model Calibration

The parameter values used to calibrate the model are given in Table 2.6. The values for the share parameters $s_i = i/Y$ $(i = C,\ MN, AG, OS,\ \bar{G},\ \bar{X}, M,\ \overline{FDI}$) are taken from the statistical abstract for Mongolia and represent means values for the sample period (see appendix table 2.1 for source). The income elasticity of consumption α_Y is set to 1.65. This value was selected based on Glytsos's (2005) work. In that study, short-run and long-run marginal propensities to consume (MPCs) were estimated for five Mediterranean countries: Egypt, Greece, Jordan, Morocco and Portugal. We converted the estimated long-run MPCs to income elasticities using mean data points from Glytsos's data set. The 1.65 is the simple average of the five elasticities. Because four of the five countries included in Glystos's analysis represent emerging economies, this procedure was deemed adequate for obtaining a "best-bet" estimate for Mongolia.

A similar procedure was used to obtain best-bet estimates for the income elasticities to invest and import. Specifically, estimates of β_Y, γ_Y and δ_Y (the income elasticities to invest in the mining, agricultural, and other sectors, respectively) were obtained by converting Glytsos's estimates of each country's marginal propensity to invest into an elasticity, and then taking a simple average of the elasticities to get a best-bet value. This yielded a best-bet value of 0.56, which we applied to all three sectors. An estimate of θ_Y (the income elasticity to import) was obtained by converting the marginal propensities to import into elasticities, and taking a simple average to yield a best-bet value of 2.16. An estimate of β_{FDI} (the elasticity of investment in the mining sector with respect to FDI) was obtained by converting Glytsos's estimates of the marginal propensity to invest remittances to elasticities, and taking the simple average to yield a best-bet value of 0.10.

Glytsos's study did not include exchange rates. Thus, for β_ε and γ_ε (the elasticities of the mining and agricultural sectors, respectively, with respect to exchange rate) we selected -0.20 as the "best-guess" values for these parameters. For θ_ε (the elasticity of imports with respect to exchange rate) our best-guess value is 1.0. These guesstimates imply that an isolated 1% increase in the value of the tugrik would decrease the size of the mining and agricultural sectors by 0.20% (owing to less competitive exports), and increase the value of imports by 1%, all else equal. Stochastic simulations are performed to account for the uncertainty associated with these and other parameters as explained later.

For φ_Y (the elasticity of exchange rate with respect to income), the best-value value was set to 0.34. This is a weighted average of the estimates obtained in the present study. It was computed using the formula $\hat{\varphi}_Y = w_{CH}\hat{\varphi}_Y^{CH} + w_{ROW}\hat{\varphi}_Y^{US}$ where $w_{CH} = 0.526$ is the average share of Mongolia's exports going to mainland China over the sample period, and $w_{ROW} = 0.474$ is the average share going to the Rest of World. The values for $\hat{\varphi}_{Y}^{CH}$ and $\hat{\varphi}_{Y}^{US}$ (0.253 and 0.435, respectively) are the long-run estimates of these parameters as reported in Table 2.5. A best-bet value for the remaining parameter in the model, namely φ_{FDI} (the elasticity of exchange rate with respect to FDI), was obtained in a similar fashion. Specifically, using the formula $\hat{\varphi}_{FDI} = w_{CH}\hat{\varphi}_{FDI}^{CH} + w_{ROW}\hat{\varphi}_{FDI}^{US}$ and the long-run estimates for these parameters reported in Table 2.5, we set $\hat{\varphi}_{FDI}$ to 0.19.

To account for the uncertainty associated with the selected parameter values, in simulating the model we assumed all the parameters (except shares) follow a GRK distribution. The GRK distribution is an empirical substitute for the triangle distribution risk (Richardson et al. 2008, pp. 14-15). It is implemented by specifying minimum, middle, and maximum values for the random variable. The triangle distribution never actually draws minimum or maximum values and thus understates downside. The GRK distribution circumvents this problem by drawing values less than the minimum and greater than the maximum about 2% of the time. In our simulations, the middle value of each parameter is set to the value given in Table 2.6, and the minimum and maximum values are set to 50% and 150% of the middle values. The stochastic simulations are performed using the software package SIMETAR (Richardson et al. 2008) with the number of draws set to 1000.

4.2. Reduced-Form Elasticities

The reduced-form elasticities for FDI corresponding to the seven endogenous variables in the structural model and their 90% confidence intervals are given in Table 2.7. When exchange rate is treated as exogenous, all the elasticities are positive and none of the 90% confidence intervals include zero. When the feedback effects of FDI on exchange rates are ignored, FDI has a positive effect on all sectors in the economy. Focusing on mean values, a 1% increase in FDI is estimated to increase the agricultural sector by 0.063%, the mining sector by 0.165%, and other sectors by 0.065%. The 90% confidence intervals for $AG^*/\overline{FDI}^*$, $MN^*/\overline{FDI}^*$ and $OS^*/\overline{FDI}^*$ are [0.025, 0.129], [0.101,0.240] and [0.0.025, 0.134], respectively. Because the confidence intervals overlap, it is not clear that the mining sector is more affected by FDI than the other sectors. What is clear, however, is that for the considered values of the structural parameters (and assumptions about their stochastic properties) FDI appears to grow all sectors *assuming exchange rate is unaffected by FDI.*

In reality, exchange rate is affected by FDI, as evidenced by our econometric analysis. When this endogeneity is taken into account, the inference that FDI has a positive effect on the sectors can no longer be maintained with any degree of confidence. Specifically, the 90% confidence intervals for $AG^*/\overline{FDI}^*$, $MN^*/\overline{FDI}^*$ and $OS^*/\overline{FDI}^*$ now include zero (Table 2.7), which means none of the elasticities are different from zero in a statistical sense. When feedback effects of FDI on the exchange rate are accounted for, the sectoral effects of FDI vanish. Induced exchange rate effects cause the mean values of $AG^*/\overline{FDI}^*$, $MN^*/\overline{FDI}^*$ and $OS^*/\overline{FDI}^*$ to decline by a factor of at least 2.6, with the mean value of $AG^*/\overline{FDI}^*$ switching from positive to negative (from 0.063 to -0.035). The sign switch is consistent with the analytical results presented in the theoretical section wherein the positive direct effect of an increase in FDI on the agricultural sector (term A in equation (15)) is offset by a negative indirect effect associated with currency strengthening (term B x C in equation (17)).

According to the theoretical analysis, a necessary condition for the DD hypothesis to hold is that the reduced-form elasticity $e^*/\overline{FDI}^*$ be positive. The 90% confidence interval for this parameter is [0.121, 0.262] (Table 2.7), which suggests the necessary condition holds.

That exchange rate effects are important to the agricultural sector can be seen by computing the numerical value for term B in equation (15) of the theoretical model implied by the estimates in Table 2.7. The computation is

(23) $$\text{Term B} \equiv \left(\frac{AG^*}{e^*}\right)_{dFDI=0} = \frac{\frac{AG^*}{FDI^*} - \left(\frac{AG^*}{FDI^*}\right)_{de=0}}{\frac{e^*}{FDI^*}} = \frac{-0.035 - 0.063}{0.192} = -0.510$$

where $\left(\frac{AG^*}{e^*}\right)$ is an elasticity that holds FDI constant and $\left(\frac{AG^*}{FDI^*}\right)$ is an elasticity that holds exchange rate constant. An isolated 1% increase in the exchange rate reduces the agricultural sector by 0.51%. Clearly, exchange rate movements have important consequences for Mongolia's agricultural sector. The relatively large size of the elasticity in equation (23) affirms the relevance of the DD hypothesis for understanding the sectoral effects of capital inflows. Still, it would appear that the agricultural sector is not much affected by movements in the exchange rate *when they are induced by FDI*, as can be seen from the following elasticity

(24) $$\frac{AG^*}{e^*} = \frac{AG^*/\overline{FDI}^*}{e^*/\overline{FDI}^*} = \frac{-0.035}{0.192} = -0.182.$$

In this instance, neglecting the fact that the 90% confidence interval for $AG^*/\overline{FDI}^*$ includes zero, a 1% increase in the exchange rate *induced by FDI* reduces the agricultural sector by a relatively modest 0.18%.

4.3. Government Multipliers

The analysis thus far suggests currency strengthening associated with increased FDI significantly reduces the ability of FDI to grow the economy. We conclude our analysis be investigating the extent to which the same inference applies to government spending. The question is of interest because our econometric analysis suggests $\varphi_Y = 0.34$ and $\varphi_{FDI} = 0.19$, which means exchange rates are nearly twice as responsive to GNP than to FDI. This suggests any growth in the economy due to increased government spending could be neutralized by the attendant increase in the value of the currency (which harms export-dependent sectors). To test this, we simulated the model using the procedures described earlier to obtain reduced-form elasticities with respect to government spending for the total economy and the three sectors. The elasticities were converted to multipliers using the formula $\frac{\partial Z}{\partial G} = \frac{Z^*}{G^*} \cdot \frac{\bar{Z}}{\bar{G}}$ where $\bar{Z} \in (Y, AG, MN, OS)$ is the mean value for the endogenous variable in question over the sample period, and $\bar{G}$ is the mean value for government spending. Thus, for example, the Keynesian multiplier was obtained using the formula $\frac{\partial Y}{\partial G} = \frac{Y^*}{G^*} \cdot \frac{\bar{Y}}{\bar{G}}$ where $\frac{Y^*}{G^*}$ is the simulated reduced-form elasticity, $\bar{Y}$ = \$3,849 million, and $\bar{G}$ = \$301 million. The mean values used in the computation of the remaining multipliers are $\overline{AG}$ = \$462 million, $\overline{MN}$ = \$618 million and $\overline{OS}$ = \$854 million.

Results suggest government multipliers are less affected by induced currency strengthening than FDI multipliers. The Keynesian multiplier is reduced from 1.51 to 1.22 when exchange rates are permitted to adjust (Table 2.8). The corresponding reductions for the sectoral multipliers are 0.103 to 0.072 for agriculture, 0.136 to 0.098 for mining, and 0.190 to 0.155 for other sectors. These results suggest a \$1 increase in government spending would increase GNP by \$1.22, and increase value-added in the agricultural, mining, and other sectors by respectively 7.3 cents, 9.8 cents, and 15.5 cents. The attenuation in the multipliers due to induced currency strengthening is 19% for the income multiplier, and 30%, 28%, and 18% respectively for the agriculture, mining, and other sectors' multipliers. By way of comparison, the attenuation in the reduced-form elasticities in Table 2.7 associated with currency strengthening (induced by increased FDI) is 95% for income, and 156%, 61%, and 94%, respectively for the agriculture, mining and other sectors. The multipliers for government spending are less affected by induced currency strengthening than the (implied) multipliers for FDI. Still, results suggest government spending is not very stimulative. Indeed, for the considered parameter values $\frac{\partial Y}{\partial G} \in [0.76, 2.04]$ with 90% certainty. Thus, the hypothesis that a $1 increase in government spending would grow the economy by less than $1 cannot be rejected.

5. Conclusions

Study results suggest foreign direct investment (FDI) attracted by the mining industry in Mongolia over the past two decades strengthens the Mongolian currency. But the appreciation does not suppress the agricultural sector as might be expected based on the Dutch Disease hypothesis. Instead, we find that while currency strengthening associated with increased FDI moderated the effect of the booming mining sector on the agricultural sector, the effect was not sufficiently strong to cause the agricultural sector to decline.

That FDI-led growth in the mining sector has no apparent effect on the size of the agricultural sector is important because it suggests policies should focus on the environmental and labor market effects of the boom. Mining is water intensive, a resource in short supply in Mongolia. Mongolia's infrastructure is poorly developed, with much of its road system unpaved. Herders have blamed dust associated with hauling coal for poisoning the pasture their animals graze on, and mining activity for drying up wells and causing health problems amongst the local population. The development of railroads, electric transmission lines, and other infrastructure necessary to accommodate the growing needs of the mining sector runs the risk of disturbing the animal migration patterns and the pastoral lifestyle of Mongolia's rural population.[15] A

[15] For details and other issues associated with Mongolia's mining boom, see https://newint.org/books/reference/world-development/case-studies/mining-mongolia-development-resource-curse/ (accessed 8 June 2016).

large portion of Mongolia's arable land is at risk of desertification due to increased grazing pressure from the growing goat herd (valued for its cashmere), and from global warming (Markowitz 2013). Increased urbanization stemming from the mining boom has created unemployment, particularly among migrants from rural areas. Policies designed to address these issues should receive priority over policies to protect agriculture *per se*.

One limitation of our study is the data. Only 20 annual observations were available for econometric analysis. This raises the usual questions about the reliability of our statistical tests. The paucity of data also limited the number of structural equations in the economic model that could be estimated. This required that for these equations "best-bet" values of the parameters be used in lieu of actual estimates. The associated uncertainty about true values is addressed by treating the parameters as random variables and simulating the model using Monte Carlo procedures. In the future as more data become available these shortcomings can be addressed. In the meantime, the study makes a useful contribution in that it provide an initial test of the Dutch Disease hypothesis as it relates to Mongolia, but also a theoretical framework for testing the hypothesis and for quantifying its effect on the economy.

FIGURES:

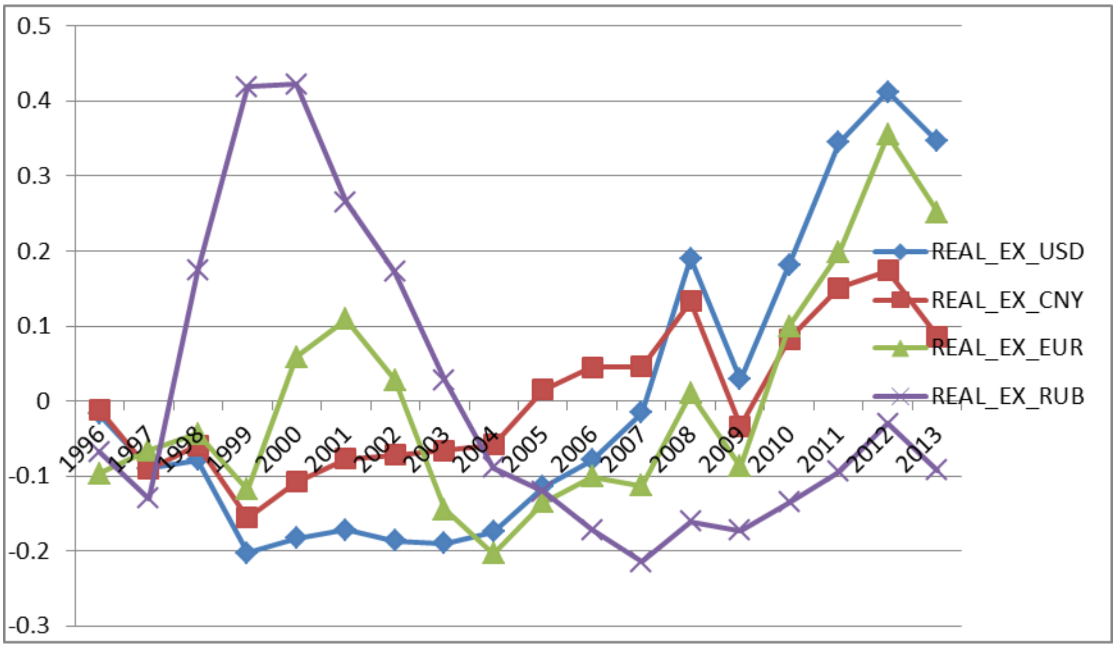

Figure 2.1 Deviations of real exchange rate from sample mean

(downward–sloping line means depreciation)

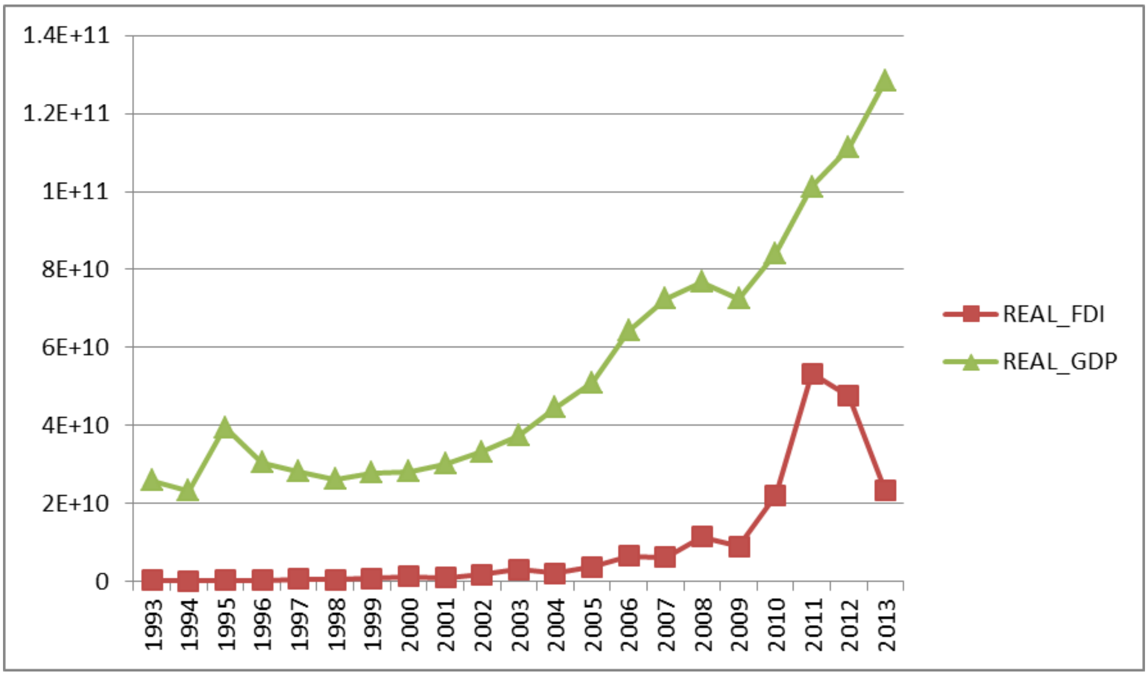

Figure 2.2 The independent variables (base year = 2010)

TABLES:

Table 2.1 Data Used to Estimate the Empirical Model

Year	Real FDI[a] (mil USD)	Real GNP[a] (mil USD)	Real FDI/ Real GNP	Real Exchange Rates			
				USD/MNT	CNY/MNT	EUR/MNT	RUB/MNT
1993	88	8763	0.010	0.00045	0.0034	0.00035	0.0564
1994	42	5629	0.007	0.00059	0.0054	0.00046	0.0410
1995	60	8825	0.007	0.00052	0.0041	0.00038	0.0264
1996	66	5568	0.012	0.00061	0.0046	0.00046	0.0241
1997	76	3578	0.021	0.00057	0.0042	0.00047	0.0225
1998	52	3115	0.017	0.00057	0.0043	0.00048	0.0304
1999	78	2723	0.029	0.00050	0.0039	0.00045	0.0367
2000	124	2624	0.047	0.00051	0.0041	0.00054	0.0368
2001	93	2754	0.034	0.00052	0.0043	0.00056	0.0328
2002	167	3005	0.056	0.00051	0.0043	0.00052	0.0303
2003	269	3265	0.082	0.00051	0.0043	0.00043	0.0266
2004	176	3767	0.047	0.00052	0.0043	0.00040	0.0236
2005	310	4234	0.073	0.00055	0.0047	0.00044	0.0228
2006	549	5450	0.101	0.00057	0.0048	0.00045	0.0214
2007	527	6200	0.085	0.00061	0.0048	0.00045	0.0203
2008	982	6583	0.149	0.00074	0.0052	0.00051	0.0217
2009	628	5049	0.124	0.00064	0.0045	0.00046	0.0214
2010	1630	6200	0.263	0.00074	0.0050	0.00056	0.0224
2011	4220	8002	0.527	0.00084	0.0053	0.00061	0.0234

2012	3501	8199	0.427	0.00088	0.0054	0.00069	0.0251
2013	1543	8423	0.183	0.00084	0.0050	0.00063	0.0235
Percent Change:							
1999-2003	244	20	187	2	11	-3	-28
2004-2008	459	75	220	44	20	27	-8
2009-2013	146	67	47	31	12	37	10

[a] Base year is 2010.

Table 2.2 ADF Tests on (Log) Levels and First Differences

Series[a]	ADF *t*-statistic	*p*-Value	Result
f	-3.73	0.047	Stationary
y	-5.29	0.003	Stationary
e_{USD}	-1.57	0.765	Non-stationary
e_{CNY}	-3.39	0.084	Non-Stationary
e_{EUR}	-1.98	0.571	Non-stationary
e_{RUB}	-1.52	0.783	Non-stationary
Δe_{USD}	-6.29	0.000	Stationary
Δe_{CNY}	-8.59	0.000	Stationary
Δe_{EUR}	-4.99	0.005	Stationary
Δe_{RUB}	-3.70	0.049	Stationary

[a] f and y are the natural logarithms of real FDI and real GNP in table 2.1; e_{USD}, e_{CNY}, e_{EUR} and e_{RUB} are the natural logarithms of the real exchange rates for USD, CNY, EUR and RUB, respectively, in table 2.1. All equations include an intercept and linear trend.

Table 2.3 Results of Tests for Serial Correlation and Cointegration in the ARDL(1,2,2) Model

Equation	Tests for Serial Correlation (*p*-values)			Test for Cointegration (*F*-statistics)[a]
	Lagrange Multiplier Test	Correlogram *Q*-Statistic	Correlogram Squared Residuals	
USD/MNT	0.053	0.067	0.441	6.72**
CNY/MNT	0.481	0.518	0.749	16.06***
EUR/MNT	0.648	0.646	0.650	2.31
RUB/MNT	0.168	0.160	0.023	2.23

[a]The lower- and upper-bound critical values for the *F*-statistic for an equation with an intercept and trend for $k = 2$ and $n = 30$ at the 10%, 5%, and 1% significance levels are [3.77, 4.64], [4.54, 5.42], and [6.43, 7.51], respectively (Narayan 2005, p. 1989).

**(***) indicates the null hypothesis of no cointegration can be rejected at the 5% (1%) level.

Table 2.4 *F*-tests of Model Restrictions

Model	USD/MNT Relation		CNY/MNT Relation	
	F-statistic (p-value)	Result	*F*-statistic (p-value)	Result
B	7.00 (0.013)	Reject	4.96 (0.032)	Reject
C	5.58 (0.012)	Reject	0.99 (0.456)	Fail to Reject
D	8.93 (0.002)	Reject	2.18 (0.138)	Fail to Reject

Note: The maintained hypothesis is Model A. See text for details.

Table 2.5 OLS Estimates of Model Parameters

Parameter/ Statistics	USD/MNT Relation (Model A)	CNY/MNT Relation Model C	Model D
λ	1.11***	1.85***	--
	(4.46)[b]	(12.7)	
φ_Y	0.435***	0.253***	--
	(5.71)[a]	(8.36)	
φ_{FDI}	0.380***	0.015	--
	(4.43)	(0.87)	
a_{y0}	-0.071	--	-0.417**
	(-0.74)		(-2.12)
a_{y2}	0.133	--	--
	(1.01)		
a_{f0}	0.172***	--	0.005
	(3.73)		(0.08)
a_{f2}	0.141**	--	--
	(2.38)		
a_{TREND}	-0.131***	-0.028***	--
	(-3.50)	(-2.82)	
a_0	-27.8***	-15.0**	0.052
	(-4.41)	(-10.9)	(1.47)
R^2	0.84	0.92	0.21
Adjusted R^2	0.71	0.90	0.12
S.E. of regression	0.0515	0.0452	0.1342

[a]Number in parenthesis is asymptotic *t*-ratio. *, **, and *** indicate significance at 1%, 5%, and 10% levels, respectively, based on a two-tail *t*-test. Model A is the ARDL(1,2,2) model, Model C is the partial adjustment model, and Model D is the static first-difference model. See text for details.

[b] The $I(0)$ and $I(1)$ bounds for the *t*-statistic corresponding to λ (the error-correction term) at the 10%, 5%, and 1% significance levels are [3.13, 3.63], [3.41, 3.95], and [3.96, 4.53], respectively (Pesaran et al. (2001), Table CII (v), p. 303).

Table 2.6 Baseline Values for Parameters of Structural Model

Parameter	Definition	Value
s_C	Share of consumption in income (Y)	0.41
s_{MN}	Share of mining in income	0.16
s_{AG}	Share of agriculture in income	0.13
s_{OS}	Share of other sectors in income	0.22
s_G	Share of government expenditure in income	0.08
s_M	Share of net imports in income	0.06
s_{FDI}	Share of FDI in income	0.06
α_Y	Elasticity of consumption with respect to income	1.65
β_Y	Elasticity of investment in mining sector wrt Income	0.56
γ_Y	Elasticity of investment in agricultural sector wrt income	0.56
δ_Y	Elasticity for the investment in other sectors wrt income	0.56
θ_Y	Elasticity of imports wrt income	2.16
φ_Y	Elasticity of exchange rate wrt income	0.34
β_e	Elasticity of mining sector wrt to exchange rate	-0.20
γ_e	Elasticity of agricultural sector wrt exchange rate	-0.20
θ_e	Elasticity of imports wrt to exchange rate	1.00
β_{FDI}	Elasticity of mining sector wrt to FDI	0.10
φ_{FDI}	Elasticity of exchange rate wrt to FDI	0.19

Table 2.7 Reduced-Form Elasticities for FDI[a]

Endogenous Variable	Exchange Rate Exogenous			Exchange Rate Endogenous		
	5% Limit	Mean	95% Limit	5% Limit	Mean	95% Limit
AG^*	0.025	0.063	0.129	-0.082	-0.035	0.002
MN^*	0.101	0.165	0.240	-0.001	0.064	0.124
OS^*	0.025	0.065	0.134	-0.036	0.004	0.029
M^*	0.144	0.224	0.344	0.152	0.192	0.219
C^*	0.063	0.203	0.442	-0.104	0.012	0.086
Y^*	0.061	0.114	0.208	-0.058	0.004	0.048
e^*	--	--	--	0.121	0.192	0.262

[a]Based on stochastic simulations of equations (8) – (14). See text for details.

Table 2.8 Government Multipliers[a]

Multiplier	Exchange Rate Exogenous			Exchange Rate Endogenous		
	5% Limit	Mean	95% Limit	5% Limit	Mean	95% Limit
$\frac{\partial Y}{\partial \bar{G}}$	0.833	1.506	2.727	0.757	1.220	2.043
$\frac{\partial AG}{\partial \bar{G}}$	0.044	0.103	0.196	0.029	0.072	0.142
$\frac{\partial MN}{\partial \bar{G}}$	0.055	0.136	0.277	0.038	0.098	0.185
$\frac{\partial OS}{\partial \bar{G}}$	0.081	0.190	0.372	0.066	0.155	0.293

[a]Based on stochastic simulations of equations (8) – (14). See text for details.

Appendix Table 2.1. Data Definitions and Sources

Variable Name	Definition	Source[a]
FDI	Foreign Direct Investment in Mongolia (mil USD)	World Bank
GNP	Mongolia's Gross Domestic Product (mil USD)	World Bank
USD/MNT	Exchange rate between U.S. dollar and Mongolia's tugrik	World Bank
CNY/MNT	Exchange rate between China's Yan and tugrik	World Bank
RUB/MNT	Exchange rate between Russia's ruble and tugrik	World Bank
EURO/MNT	Exchange rate between the Euro and tugrik	UBC
CPI_M	Consumer Price Index for Mongolia	World Bank
CPI_US	Consumer Price Index for U.S.	World Bank
CPI_CH	Consumer Price Index for China	World Bank
CDI_R	Consumer Price Index for Russia	World Bank
CPI_E	Consumer Price Index for Europe	Rate Inflation
s_C	Share of consumption in the economy	World Bank
s_{MN}	Share of mining in the economy	World Bank
s_{AG}	Share of agriculture in the economy	World Bank
s_{OS}	Share of other sectors in the economy	World Bank
s_G	Share of government expenditure in the economy	World Bank
s_{XX}	Share of exports in the economy	World Bank
s_{MM}	Share of imports in the economy	World Bank
s_M	Share of net imports in the economy ($= s_{MM} - s_{XX}$)	World Bank
s_{FDI}	Share of FDI in the economy	World Bank

[a] Sources are as follows:

World Bank - http://data.worldbank.org/indicator/BX.KLT.DINV.CD.WD (accessed 25 March 2016); UBC - http://fx.sauder.ubc.ca/ (accessed 25 March 2016. Obtained the EURO/USD rate from this source. The EURO/MNT rate was then obtained by multiplying EURO/USD by USD/MNT); Rate Inflation - http://www.rateinflation.com/consumer-price-index/euro-area-historical-cpi?start-year=1993&end-year=2013 (accessed 25 March 2016).

Chapter 3. Dynamic analysis of the livestock inventory in Inner Mongolia

1. Introduction

Inner Mongolia Autonomous Region (IMAR) is one of the five autonomous regions and the largest pasture in China, where the grazing is one of the most important industries. Among the 12 prefectures (or cities) in IMAR, three regions (figure 3.1) are widely distinguished based on their locations: the west region (Alexa, Wuhai, Bayannur), the central region (Baotao, Hohhot, Ordos, Ulanqab), and the east region (the remaining). Because of the grassland, IMAR also plays an important role in maintaining the ecosystem. The research related to livestock inventory has interested economists for many decades. Compared to other agricultural commodities, livestock is special because it has a nature of the biological lags which delay the response of the inventory to the market. As a result, both past and anticipated prices are important determinants of production plans. As mentioned, grazing has close correlation with ecosystem. For example, overgrazing is considered as the main cause of grassland degradation in northern China (Han et al., 2008; Zhao et al., 2006; Li and Ji 2004) which in turn threatens this industry. From both economic and ecologic perspective, it is meaningful to analyze the determinants of the livestock inventory in IMAR.

Research about livestock inventory is complex because the dynamic cycle is hard to be simulated by economic models. But still this area is of great interest to economists. Jarvis (1974); Melton (1980); Rucker, Burt, and LaFrance (1984); Trapp (1986); Chavas and Klemme (1986); and Schmitz(1997) investigated the dynamic behavior underlying the livestock inventory through analyzing the replacement and culling decisions. In their studies, cattle are treated as capital. The models are mainly based on biological factors. The economic and environmental influences are considered as they affect the probability of replacement and culling decisions.

Jarvis examined the inventory of cattle by treating cattle as capital goods and producers as portfolio managers. The managers sought the optimal combination of different categories of animals to complement their non-cattle assets and then to maximize profit. This process results in the expected inventory of cattle. Melton extended Jarvis's study by considering the role of genetic improvement which was done on the experimental herd. Chavas and Kleme investigated the milk supply and the change of dairy herd. They considered a model of population growth, where the replacement decision and the culling decision would be affected by the milk price, slaughter price, and feed cost. Similar to Chavas and Kleme's work, Schmitz set up a replacement probability to introduce the economic and environmental effect (interest rate, Palmer Drought Severity Index, etc.) into the age dynamics model.

Trapp's model is different from those mentioned above. He employed financial thoughts in his work where replacement and culling were treated as investment and disinvestment respectively in a firm. The firm's cost curve and the discounted net revenue flows affected the firm size (inventory of the beef-breeding herds). And, instead of estimating the dynamic adjustment process underlying cattle inventory behavior (replacement and culling), Rucker, Burt, and LaFrance employed a rational lag function including cattle prices, feed cost, and weather variables as an approximation.

One of the similarities of the past research is that it focuses more on the change of the inventory through a biological process than in the market, even though the effect of the market has been included through its impacts on the replacement decision. In fact, market and farm are separate and they interact by price. Therefore it is logical to analyze market and farm separately and then to examine their interaction in terms of prices. In the market, supply shifters and demand shifters can impact the price, and then the changes of price will impact the inventory in the farm. In other words, price is endogenous. Tryfos (1974) separated livestock supply and inventories in his work. The relationship between supply and inventory is that the supply is the changes of inventories in different periods. Price is still exogenous. It affected the inventory first and then the supply. Arzac and Wilkinson (1979) realized that feed grain prices were endogenous so that the dynamics of the interaction between the livestock and feed grain markets might be analyzed. They incorporated the endogenous variables by allowing individual structural equations to be estimated and to enter into the solution of the model with different periodicities.

Besides the ignorance of the activities in a market and the endogeneity of the prices, another limitation of previous research is that most research lacks the influence of the environment. Fortunately, some recent studies have noticed the environmental influence on the inventory. For example, Belasco (2013) analyzed the impact of droughts on ranchers' decision regarding herd size by using state-wide panel data series from 1945 to 2012 and a first-difference fixed effects panel estimator.

Most research tries to make the dynamics of the inventory more close to the reality by addressing different assumptions or introducing variables to the econometric model. The methodology developed in the previous studies provides both theoretical and econometrical bases for our research. However, most research ignores the logic underlying the inventory and the market, in particular their interaction. In this case, we attempt to make it clear by connecting farm and market through endogenizing prices.

The organization of this paper is as follows. The second section specifies the model; the third explains the variables and data; the fourth discusses the estimation and results; and the fifth summarizes the main findings of the paper.

2. Model specification

Theoretical model

A static partial-equilibrium model is constructed to describe the situation of Inner Mongolia's livestock sector. Complexities such as product heterogeneity, price wedges due to subsidies or tariffs, imperfect competition, and demand and supply interrelationships are ignored. Because more than 70% of livestock products and 85% milk are exported to other areas of China, IMAR is treated as an open economy in the model.

The basic model consists of four equations

$$Q_s^* = \varepsilon_d (P^* + \alpha) \quad (1)$$

$$Q_d^* = \eta_d (P^* - \beta) \quad (2)$$

$$Q_x^* = \eta_x (P^* - \gamma) \quad (3)$$

$$Q_s^* = k_d Q_d^* + k_x Q_x^* \quad (4)$$

where Q_s^*, Q_d^*, and Q_x^* are proportionate changes in domestic production, consumption, and exports, respectively, (e.g., $Q_d^* = dQ_d/Q_d$ is proportionate change in domestic consumption); P^* is the proportionate change in the price of the livestock item in question; ε_d (> 0) is the domestic supply elasticity; $\eta_d (< 0)$ is the domestic demand elasticity; $\eta_x (< 0)$ is the export demand elasticity; α (> 0) is a parameter that represents the proportionate *downward* shift in the domestic supply curve due to some exogenous factor, i.e., the shift in the price direction holding quantity constant; β (> 0) is a parameter that indicates the proportionate *upward* shift in the domestic demand curve due to some exogenous factor; γ (> 0) is the proportionate *upward* shift in the export demand curve due to some exogenous factor; $k_d = Q_d/Q_s$ is the share of domestic production consumed within Inner Mongolia; and $k_x = Q_x/Q_s$ is the share of domestic production exported ($k_d + k_x = 1$).

The model contains four endogenous variables (Q_s^*, Q_d^*, Q_x^*, and P^*) and three exogenous variables or shift parameters (α, β, and γ). At issue is the effect of the supply and demand shifters on the *equilibrium* level of livestock production. The equilibrium level of production is the level that takes into account price changes induced by supply or demand shifts. To determine that, we first solve the model for the price effect of the shift variables

$$P^* = -\left(\frac{\varepsilon_d}{D}\right)\alpha - \left(\frac{k_d\eta_d}{D}\right)\beta - \left(\frac{k_x\eta_x}{D}\right)\gamma \qquad (5)$$

where $D = (\varepsilon_d - k_d\eta_d - k_x\eta_x) > 0$. An increase in domestic supply ($\alpha > 0$) reduces equilibrium price, while an increase in domestic demand ($\beta > 0$) or export demand ($\gamma > 0$) increases equilibrium price.

Substituting equation (5) into equation (1) yields the reduced-form equation for domestic production:

$$Q_s^* = -\left(\frac{\varepsilon_d(k_d\eta_d + k_x\eta_x)}{D}\right)\alpha - \left(\frac{\varepsilon_d k_d\eta_d}{D}\right)\beta - \left(\frac{\varepsilon_d k_x\eta_x}{D}\right)\gamma \qquad (6)$$

An increase in domestic supply increases the equilibrium level of livestock production, as does an increase in domestic or export demand.

If Inner Mongolia is a small exporter such that it faces a perfectly elastic demand curve in the export market, equations (5) and (6) reduce to

$$P^* = \gamma \qquad (\eta_x = -\infty) \qquad (7)$$

$$Q_s^* = \varepsilon_d(\alpha + \gamma) \qquad (\eta_x = -\infty) \qquad (8)$$

In this instance, domestic demand shifters have no effect on the equilibrium level of livestock production. The reason is that with perfectly elastic export demand, shifts in domestic demand have no effect on equilibrium price, and without a price effect there is no production response. This is shown in figure 3.2 where a rightward shift in the domestic demand curve from *D* to *D*' causes offsetting changes in domestic consumption and exports, leaving domestic production unchanged at its initial equilibrium level Q_s.

Inventory Relation

The model is completed with an equation for livestock inventory. Following Rucker *et al*. (1984), we posit the following structural relation

$$\tilde{I}_t = f(\tilde{P}_t, \tilde{F}_t, W_t) \qquad \frac{\partial \tilde{I}_t}{\partial \tilde{P}_t} \gtrless 0,\ \frac{\partial \tilde{I}_t}{\partial \tilde{F}_t} < 0,\ \frac{\partial \tilde{I}_t}{\partial W_t} > 0 \qquad (9)$$

where $\tilde{I}_t$ is the desired herd size in period t, $\tilde{P}_t$ is the expected price for the livestock item in question (e.g., sheep), $\tilde{F}_t$ is the expected price of feed and/or feed availability, and W_t is weather conditions. Defining W_t as a weather index where larger values indicate more favorable conditions for grazing, an isolated increase in W_t is expected to increase the desired herd size. An isolated increase in expected feed cost (or a decrease in expected feed availability) is expected to decrease the desired herd size.

Importantly, expected livestock price has an ambiguous effect on desired herd size. The reason is that livestock properly is viewed as a capital good (Jarvis 1974). Consequently, an increase in the price of the livestock item has two opposing effects on producers' decisions. As noted by Rucker *et al*. (1984, p. 135), the price increase causes producers to expect higher prices in the future, which provides an incentive to increase breeding stock to take advantage of the higher future price. Jarvis (1974) refers to this as the "investment demand" for livestock. On the other hand, the price increase encourages producers to sell livestock immediately to profit from the current high price. This is analogous to Jarvis's "consumption demand" for livestock. Depending on which motive dominates (the investment motive or the consumption motive), equation (9) may be upward-sloping or downward-sloping with respect to expected price.

To implement equation (9) an equation must be found to represent desired herd size $\tilde{I}_t$, as this variable is unobservable. For this purpose, we adopt the partial adjustment model

$$\frac{I_t}{I_{t-1}} = \left(\frac{\tilde{I}_t}{I_{t-1}}\right)^{\lambda} \qquad (0 < \lambda \le 1) \tag{10}$$

where I is observed herd size, and λ is the "elasticity of adjustment" (Nerlove 1958). The relationship between observed and desired herd size may be found through proportionate differentiation of equation (10). Suppressing time subscripts and rearranging terms, the equation of interest is

$$I^* = \lambda \tilde{I}^* + (1-\lambda) I^*_{t-1}. \tag{11}$$

The proportionate change in desired herd size in any given period lies between the proportionate change in observed herd size in that period and the proportionate change in observed herd size in the previous period. If adjustment costs are low such that $\lambda \approx 1$, the observed adjustment in the current period is close to the desired adjustment, i.e., $I^* \approx \tilde{I}^*$. In this situation, producers are able to respond quickly to supply and demand shocks and the observed herd size in any given period is close to the desired herd size. The opposite is true if adjustment costs are high such that $\lambda \approx 0$. In this situation $I^* \approx I^*_{t-1}$ and the time required to achieve the desired herd size in response to a supply or demand shock can be quite lengthy.

Equations (11) and (9) may be linked by taking the total differential of the latter and converting partial derivatives to elasticities to yield (time subscripts suppressed)

$$\tilde{I}^* = \delta_{\tilde{P}} \tilde{P}^* + \delta_{\tilde{F}} \tilde{F}^* + \delta_W W^*$$

(12)

where $\delta_{\tilde{P}} \left(\gtrless 0\right)$, $\delta_{\tilde{F}}(< 0)$, and δ_W (> 0) are partial elasticities of desired herd size with respect to expected price, expected costs, and weather, respectively.

Substituting equation (12) into equation (11) yields

$$I^* = \lambda\delta_{\tilde{P}} \tilde{P}^* + \lambda\delta_{\tilde{F}} \tilde{F}^* + \lambda\delta_W W^* + (1-\lambda) I^*_{t-1}. \tag{13}$$

Observed herd size is a function of expected price, expected costs, weather, and observed herd size in the previous period. The coefficients of $\tilde{P}^*$, $\tilde{F}^*$and W^* are short-run elasticities. The short-run elasticities approach their long-run counterparts as $\lambda \to 1$. If $\lambda = 1$ adjustment costs are zero and equation (13) reduces to equation (12), the static specification.

It remains to eliminate expected price and expected costs, as these variables are unobservable as well. For this purpose, we assume naïve expectations. Setting $\tilde{P}^*$ and $\tilde{F}^*$ equal to their observed values in the current period, equation (13) may be rewritten as

$$I^* = \pi_0 + \pi_{\tilde{P}} P^* + \pi_{\tilde{F}} F^* + \pi_W W^* + \pi_{LDV} I^*_{t-1} \qquad (14)$$

where $\pi_{\tilde{P}} = \lambda\delta_{\tilde{P}} \gtrless 0$, $\pi_{\tilde{F}} = \lambda\delta_{\tilde{F}} < 0$, $\pi_W = \lambda\delta_W > 0$, and $0 \leq \pi_{LDV} = (1-\lambda) < 1$. Observed herd size is a function of observed livestock price, observed inventory costs, weather conditions, and observed herd size in the previous period (lagged dependent variable or LDV). An intercept π_0 is included in equation (14) to account for autonomous shifts in the inventory relation due to factors that change gradually over time but that are not specified in the model.

Total Elasticities

Equation (14) is a structural equation. As such, the coefficients of $F^*$and W^* tell the effect of changes in inventory costs and weather on desired herd size when livestock price is held constant. In reality, livestock price will change in response to changes in F or W unless Inner Mongolia is a small exporter, i.e., it faces a perfectly elastic demand curve in the export market.

To account for the potential endogeneity in livestock price, and to incorporate demand shifters into the inventory relation, first rewrite equation (5) in the simpler form

$$P^* = \varphi_\alpha \alpha + \varphi_\beta \beta + \varphi_\gamma \gamma \qquad (5')$$

where $\varphi_\alpha = \frac{-\varepsilon_d}{D} < 0$, $\varphi_\beta = \frac{-k_d\eta_d}{D} > 0$, and $\varphi_\gamma = \frac{-k_x\eta_x}{D} > 0$. Substituting equation (5') into equation (14) yields

$$I^* = \pi_0 + \pi_S S^* + \pi_D D^* + \pi_X X^* + \pi_{\tilde{F}} F^* + \pi_W W^* + \pi_{LDV} I^*_{t-1} \qquad (15)$$

where S^* is a vector of domestic supply shifters associated with livestock *harvests* Q_s^* (as opposed to livestock inventory I^*) expressed as proportionate changes, D^* is a vector of domestic demand shifters, and X^* is a vector of export demand shifters. The parameters associated with these shift variables have indeterminate signs as follows

$$\pi_S = \pi_{\hat{\beta}} \varphi_\alpha \gtreqless 0 \tag{16a}$$

$$\pi_D = \pi_{\hat{\beta}} \varphi_\beta \gtreqless 0 \tag{16b}$$

$$\pi_X = \pi_{\hat{\beta}} \varphi_\gamma \gtreqless 0 \tag{16c}$$

With the maintained hypothesis that feed and other costs associated with herd maintenance are exogenous to the livestock subsector under consideration (e.g., sheep), the coefficients of equation (15) can be interpreted as *reduced-form* elasticities. Specifically, $\pi_{\hat{\beta}}$ tells the percentage change in herd size associated with an isolated 1 percent change in inventory costs, *letting livestock price adjust*. A similar interpretation applies to π_W. Because "total" elasticities that let price adjust in general are smaller than "partial" elasticities that hold price constant (Piggott 1992), the estimates of $\pi_{\hat{\beta}}$ and π_W obtained from the reduced form (equation (15)) are expected to be smaller than the estimates obtained from the structural equation (equation (14)).

Small Exporter Hypothesis

If Inner Mongolia is a small exporter $\varphi_\alpha = \varphi_\beta = 0$ and domestic supply and demand shifters have no effect on price (see equation (7)). In this instance, equation (15) reduces to

$$I^* = \pi_0 + \pi_X X^* + \pi_{\hat{\beta}} F^* + \pi_W W^* + a_{LDV} I^*_{t-1} \qquad (\eta_x = -\infty). \tag{16}$$

If Inner Mongolia is too small a player in world markets to affect terms of trade, the only variables to affect herd size are export demand shifters, inventory-specific costs, and weather. Since equation (15) nests equation (16), the small exporter hypothesis may be tested with a standard *F*- or *Wald*-statistic.

3. Variables and data

Table 3.1 identifies the variables. The data regarding the prices of sheep, goats and cattle in IMAR are less accessible so prices of respective products (e.g., wool, cashmere, and milk) are used as the indicators of livestock prices. It is apparent, for example, the increase in the price of wool will cause the rancher to expect a higher price of sheep. There is no data used to indicate forage cost. The weather variables are reflected by temperature, precipitation and radiation. Regarding the shifters, the average income per capita in Inner Mongolia is the domestic demand shifter; the average income per capita and transportation in China represent the export shifters; and the weather is the domestic supply shifter. The increase in the average income per capita in Inner Mongolia will increase the domestic demand. The increase in the income as well as the improvement of the transportation in China will increase the exports. The grazing depends on the weather condition so the weather variables are selected as supply shifters.

The data are from the Bureau of Statistics in both local and national China and include all the variables above. The data are panel data, where observations are yearly and span from 1980 through 2010 for the 12 prefecture-level regions in IMAR. The basic statistics of variables are shown in table 3.2, where prices have been adjusted by consumer price index (CPI). As shown in table 3.2, sheep and goats are the main livestock in IMAR. The differences of the variables among the cities are significant. The development of economy in IMAR is unbalanced. The largest average number of sheep, goats, and cattle is approximately 5.4 million, 2.6 million, and 0.9 million in Xilingol, Ordos, and Tongliao, respectively. The highest average annual income per capita is about US $3.61 in Baotou, which is higher than that of capital city in Inner Mongolia - Hohhot ($3.03). The largest population is 4.1 million in Chifeng. Figure 3.3 indicates the change of the relative prices. The relative price of cashmere was most obvious exhibiting 100 times variation from the early 1980s to 2010, especially there was a sharp increase from 18.95 in 1999 to 88.84 in 2000. The relative price of wool showed decreasing first and then increase, while the price of milk decreased over time. The dynamics of livestock inventory is illustrated in figure 3.4. Generally the livestock inventory increased from 1980 to 2010, in particular, the inventory of sheep, jumped in 2000. The inventory of cattle was relatively stable.

4. Model estimation and results

The log linear forms of the structural equation (14) and reduced equation (15) are:

$$lnI = \pi_0 + \pi_{\hat{P}}\, lnP + \pi_W lnW + \pi_{LDV} lnI_{t-1} + G \qquad (14')$$

$$lnI = \pi_0 + \pi_D lnD + \pi_X ln\, X + \pi_W lnW + \pi_{LDV} lnI_{t-1} + G \qquad (15')$$

The variables are the same as in equations (14) and (15) except that there is no forage cost variable, no supply shifter in equation (15’) because W work as the supply shifters after endogenizing P. P is the prices (adjusted by CPI) of wool, cashmere and milk; W is the index of the temperature, precipitation, and radiation, and also represents the domestic supply shifters; I_{t-1} is one-year lagged livestock inventory; D represents the domestic demand shifter, which is the average income per capita in Inner Mongolia; X represents the excess demand shifters, which include the average income per capita and transportation in China; G is a dummy variable reflecting the implementation of the government grassland protection policy in 2000.

As analyzed, the equation (14’) represents the effect of the price, weather, and previous livestock inventory on the present inventory. Meanwhile we expect that the increase in the price will increase the inventory, the weather will benefit the pasture and then increase the inventory, and the adjustment indicator (π_{LDV}) will be positive but less than 1. Since the price is endogenized in the reduced equation (15’), the effect the weather will be weakened when let the prices adjust.

Fixed effect regression is employed to analyze the panel data. There are three kinds of products: wool, cashmere and milk corresponding to three kinds of livestock sheep, goats and cattle. The results are shown in table 3.3. The estimation models include the lagged dependent variables and autocorrelation exists (see Durbin-h test in table 3.3). By using the autoregressive error model, we obtain the unbiased results.

Prices are not endogenized in structural models. The estimation of the structural models shows that the inventory of sheep, goats and cattle are affected by different factors, but none is affected by the grassland protection policy. The price of wool affects the inventory of sheep significantly. 1% increase in the price of wool reduces the inventory of sheep by 0.24%. Sheep are used for mutton or wool. When the price of wool goes up, more sheep are used for wool instead of mutton. Since each sheep can produce certain amount of wool for several years so the herders don't need to breed sheep generation by generation and then the inventory of sheep will go down. In addition, more precipitation and radiation will increase the inventory of sheep. The inventory of goats is affected by the price of cashmere, temperature, precipitation, radiation and the previous inventory. 1% increase in the price of the cashmere will increase the inventory of goat by 0.07%. That is different from the relationship between sheep and wool. The reason might be that sheep can be used for mutton and wool but goats are mainly used for cashmere. Therefore when the price of cashmere goes up, the inventory of goats increases to produce more cashmere. The inventory of goats will also increase when the temperature increases. More precipitation and radiation however decreases the inventory of goats. The coefficient of the lagged inventory of goat is 0.05 which is the adjustment indicator. It means that the adjustment cost for goats is low so the herders can adjust the inventory of goats easily. The price of milk, temperature and radiation affect the inventory of cattle significantly. 1% increase in the price of milk will decrease the inventory of cattle by 0.77%. The reason may be the same with sheep. The milk production per cow is stable so most cattle can be kept for several years to produce milk instead of slaughter and then the inventory decreases a little. Moreover, lower temperature and more radiation will increase the inventory of cattle.

After endogenizing the prices, we obtain the reduced form of the model. The estimation results of the reduced form are shown in the second column. The inventory of sheep is affected by precipitation, radiation, previous inventory and local income in IMAR. More precipitation and radiation will increase the inventory of sheep. The adjustment indicator for sheep is 0.03 which is however not significant in the structural model. 0.03 means the adjustment cost is lower and it is easy to adjust the inventory of sheep. 1% increase in the local income will increase the inventory of sheep by 0.22%. About the inventory of goats, it will increase when the temperature increases or when the precipitation and radiation decrease. The adjustment indicator is 0.06 which is almost the same with that obtained from the structural model. The low adjustment cost let the herders of goat to adjust their inventory easily. In addition, 1% increase in the average income in China will increase the inventory of goats by 0.44%. When the price can adjust, the inventory of cattle is only affected by local income in IMAR. 1% increase in the local income will increase the inventory of cattle by 0.33%. The results of F-test are significant and it means that the IMAR is a large exporter. As expected, the total elasticities are smaller than the partial elasticities except that the elasticity of temperature is the same with that in the structural model. In the end, the impact of the grass protection policy is not significant either.

5. Conclusions

This paper examines the factors affecting the inventory of livestock in IMAR. Specially, we attempt to understand the dynamics of the inventory of livestock. Based on the livestock products market, we constructed an equilibrium displacement model (EDM) to describe the demand and supply of the wool, cashmere and milk which are the products of sheep, goats and cattle. Then we referred to Rucker et al. (1984)'s work to establish an inventory equation which combines the EDM and the inventory. In other words, the final equation includes not only the information from the market of wool, cashmere and milk but also the information from the livestock breeding level.

The estimation results show that the effect of the grassland protection policy is not significant for all the livestock. The increase in the price of wool will decrease the inventory of sheep and the increase in the price of milk will also decrease the inventory of cattle. It is different from the "consumption demand" which says the herders will sell the livestock to profit from the present value. Here the herders are supposed to keep the sheep and cattle to produce milk and wool. So we guess that the herders will keep their sheep and cattle for years instead of slaughter because the production of wool and milk per animal is stable and can satisfy the demand in the market. The increase in the price of cashmere will increase the inventory of goats. We guess it is because goats are mainly used for cashmere so it is wise to breed more goats to increase the supply of cashmere in the market. All the livestock are sensitive to the weather condition. But the sensitivities are different. Higher temperature will decrease the inventory of cattle but increase the inventory of goats. More precipitation will increase the inventory of sheep but decrease that of goats. More radiation will increase the inventory of cattle and sheep but decrease the inventory of goats. Only the inventory of goats is related to the previous inventory. The adjustment cost for the inventory of goats is low. Thus it is easy for the herders to adjust the inventory of goats in time.

One of the contributions in our study is that we endogenize the prices which are affected by domestic demand, supply and export shifters. After endogenizing, the elasticities of weather variables become smaller because the prices are not constant. The results show that IMAR is a large exporter which means that it can affect the prices in the market. The inventories of cattle and sheep are affected by domestic factors. The increase in the income in IMAR will increase the inventory of cattle and sheep. However the inventory of goats is only affected by the factors from the rest parts of China. The increase in the average income in China will increase the inventory of goats.

Our results also indicate that the effect of policy on the livestock inventory is not significant. The livestock inventory is more sensitive to the weather and the prices and demand of the respective products than the policy. Therefore it is better to complement policies which can affect the price or demand in the market to control the livestock inventory and then reduce the grazing to protect the grassland.

FIGURES:

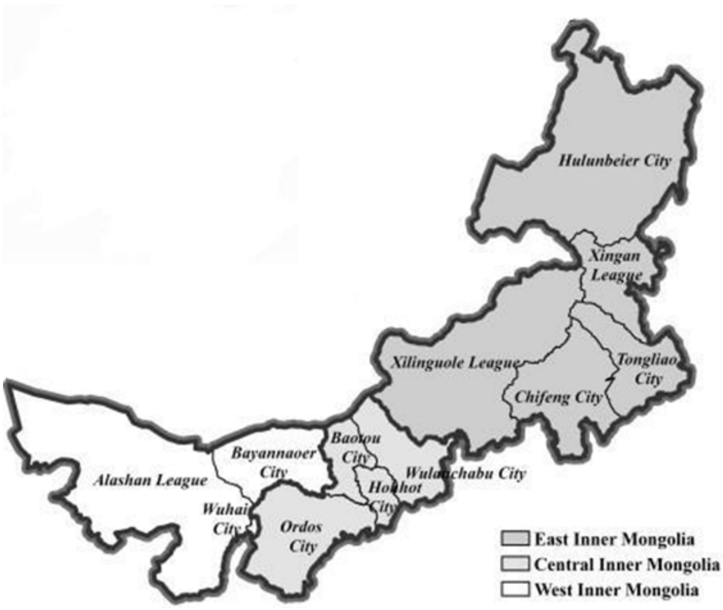

Figure 3.1 Distribution of 12 prefecture-level cities in Inner Mongolia.

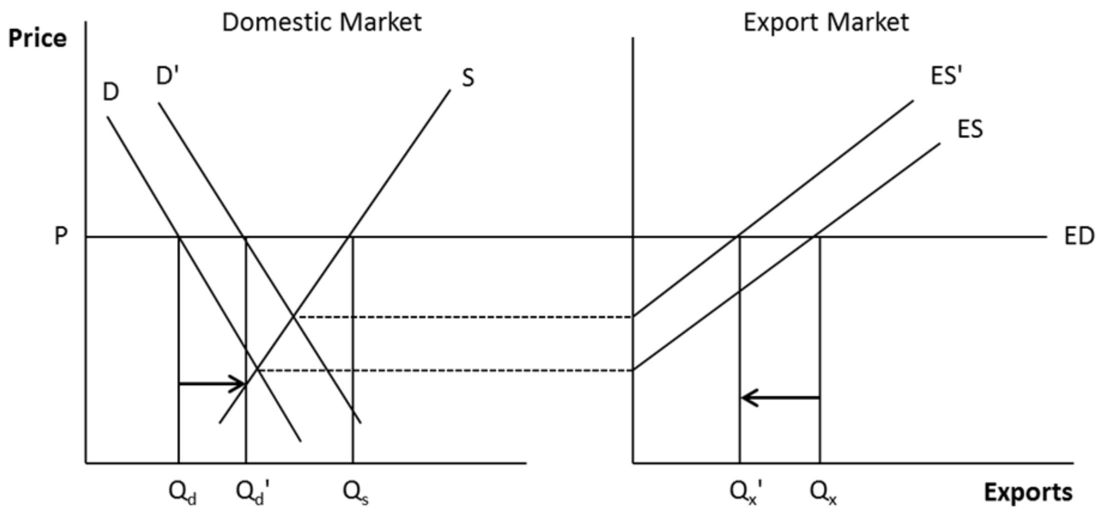

Figure 3.2 Effects of an increase in domestic demand on domestic production for a small exporter.

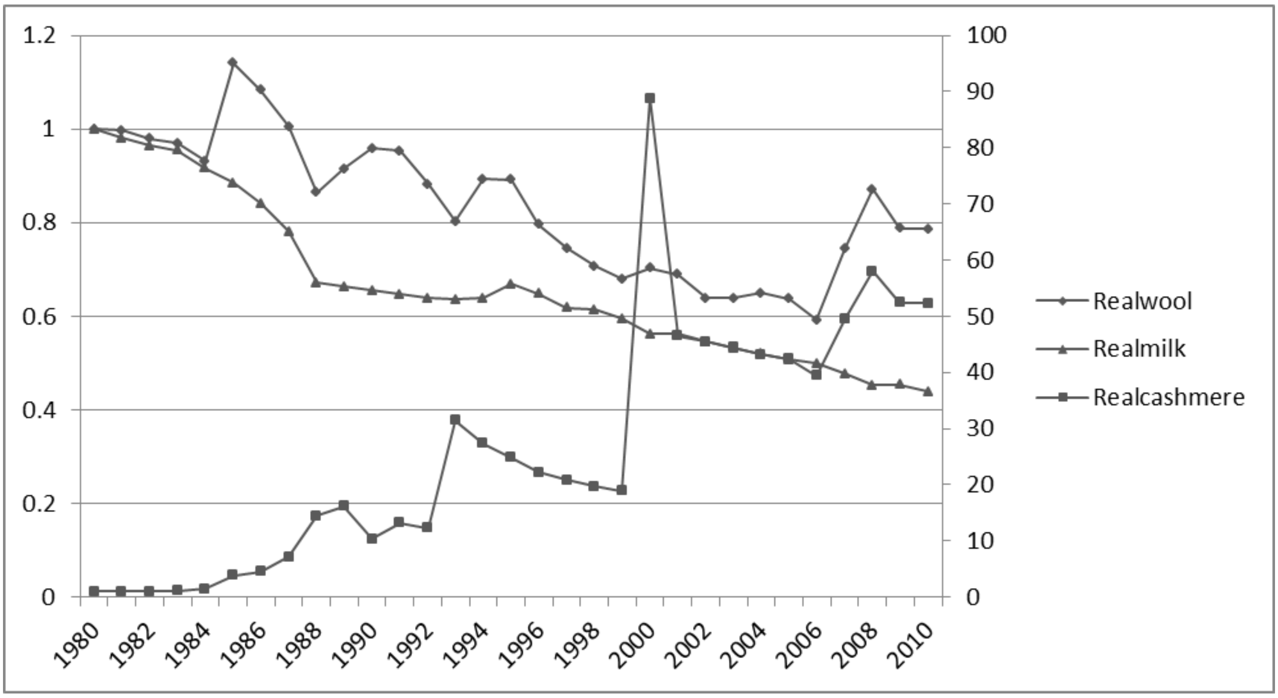

Figure 3.3 The relative price of livestock products in Inner Mongolia (1980-2010)

Note: The prices are deflated using 1980 as baseline. The right side scale is only for Cashmere

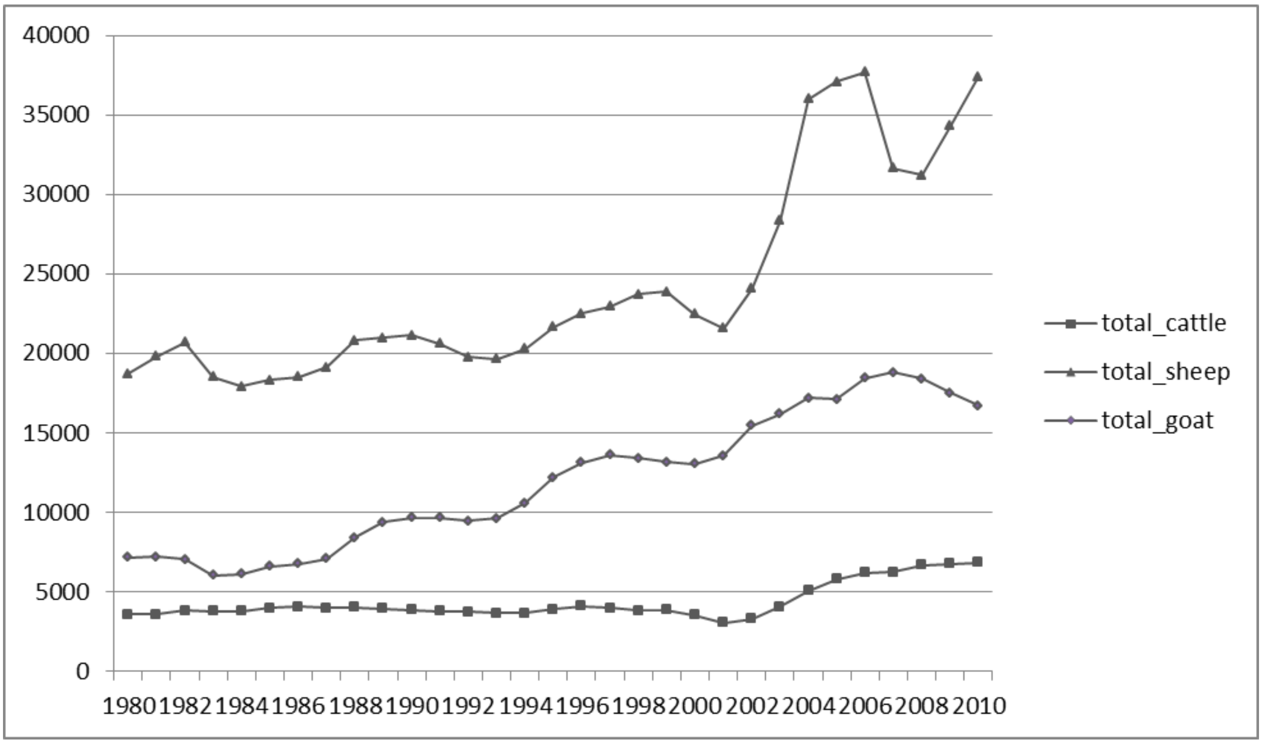

Figure 3.4 Total number of livestock in Inner Mongolia (1947-2009).

Note: Arrows represent the years of the implementation of government policies.

Data Source: Inner Mongolia Statistic Yearbook, 2010.

TABLES:

Table 3.1 Variable Definitions

Variable	Definition	Mean	Std Dev
$Price_{wool}$	Real price of wool ($)	0.83	0.15
$Price_{cashmere}$	Real price of cashmere ($)	24.81	20.29
$Price_{milk}$	Real price of milk ($)	0.64	0.18
Supply shifters:			
Temperature	Annual temperature in IMAR (^{o}C)	3.71	0.63
Precipitation	Annual precipitation in IMAR (mm)	252.60	32.97
Radiation	Annual radiation in IMAR (w.m^{-2})	78.82	0.99
Demand shifter:			
$Income_{IMAR}$	Average income per capita in all the cities of IMAR ($)	2.70	1.97
Export shifter:			
IncomeChina	Average income per capita in China ($)	5.89	3.74
TransportationCH	Total road length in China (1000 km)	166.11	102.35

Table 3.2 Basic statistics of variables for 12 cities in Inner Mongolia from 1980 through 2010.

City	Livestock Numbers (in 1,000)			Prices (Real relative price)			Income per capita (in 1,000 USD)	Population (in 1,000)
	Sheep	Goat	Cattle	Wool	Cashmere	Milk		
Alxa	407.34	789.92	10.18	0.74	21.25	0.59	2.55	174.09
	(71.22)	(126.46)	(5.98)	(0.21)	(16.82)	(0.22)	(1.52)	(27.04)
Bayannur	2856.68	1519.87	75.85	0.84	27.21	0.66	2.93	1600.05
	(1343.55)	(320.68)	(40.73	(0.13	(23.29	(0.16)	(1.97)	(154.81)
Baotou	1187.71	543.59	155.08	0.83	25.48	0.66	3.61	2027.35
	(236.22)	(142.08)	(156.93)	(0.17)	(20.74)	(0.18)	(2.91)	(318.34)
Chifeng	2565.73	1743.51	762.28	0.82	25.83	0.65	2.49	4117.19
	(821.83	(587.11)	(141.91	(0.15)	(21.29)	(0.17)	(1.45)	(342.48)
Hingan	1680.39	813.63	365.47	0.83	26.29	0.66	2.16	1543.71

	(929.26)	(703.53)	(59.24)	(0.15)	(21.89)	(0.17)	(1.28)	(92.34)
Hohhot	826.99	265.15	256.11	0.76	22.51	0.61	3.03	2066.29
	(123.19)	(92.26)	(253.77)	(0.19)	(18.00)	(0.20)	(2.46)	(387.66)
Hulunbuir	2604.08	534.84	597.43	0.82	25.76	0.65	2.64	2546.77
	(1772.45)	(415.37)	(203.06)	(0.14)	(21.50)	(0.17)	(1.66)	(143.03)
Ordos	2394.00	2607.31	98.32	0.75	22.32	0.60	2.86	1271.02
	(443.50)	(1115.46)	(78.47)	(0.17)	(17.80)	(0.19)	(2.36)	(143.84)
Tongliao	1558.75	1073.33	901.16	0.80	24.95	0.64	2.38	2861.35
	(739.28)	(816.11)	(258.47)	(0.16)	(20.65)	(0.18)	(1.53)	(242.17)
Ulanqab	2731.60	323.55	302.64	0.82	25.83	0.65	2.28	2551.51
	(933.27)	(141.41)	(74.59)	(0.15)	(21.60)	(0.17)	(1.55)	(229.26)
Wuhai	21.00	31.03	1.35	0.83	25.72	0.66	3.03	362.48

	(14.65)	(12.07)	(1.36)	(0.16)	(21.38)	(0.18)	(2.47)	(102.13)
Xilingol	5401.09	1639.08	794.14	0.79	24.55	0.63	2.44	901.09
	(963.37)	(810.41)	(170.83)	(0.15)	(20.35)	(0.17)	(1.55)	(76.14)

Note: Mean and standard deviation (in parentheses).

Table 3.3 Fixed effect estimation results

Variable	Structural Equation (14')			Reduced Equation (15')		
	Sheep	Goats	Cattle	Sheep	Goats	Cattle
$Price_{wool}$	-0.24***					
$Price_{cashmere}$		0.07***				
$Price_{milk}$			-0.77***			
Temperature	0.09*	0.21***	-0.15*	0.07	0.21***	-0.13
Precipitation	0.13**	-0.13**	0.07	0.10*	-0.11*	0.04
Radiation	2.41***	-1.76***	2.09**	2.12***	-1.65***	1.57
$Cattle_{t-1}$			-0.01			-0.01
$Sheep_{t-1}$	0.00			0.03*		
$Goat_{t-1}$		0.05***			0.06***	
Policy	-0.01	-0.08	0.04	-0.03	0.00	0.00
$Income_{IMAR}$				0.22**	-0.05	0.33*
IncomeChina				0.11	0.44***	-0.05
TransportationCH				-0.02	0.00	0.18
Constant	-4.32	14.22*	-4.12	-3.79		-2.48

					12.65***	
Durbin − h	11.44***	8.18***	10.25***	2.48***	9.54***	10.92***
Regress R^2	0.91	0.85	0.84	0.91	0.85	0.85
F − test				5.18***	6.85***	2.05*

* Significant at 10% level;

** Significant at 5% level;

***Significant at 1% level;

Variables are expressed in logarithms.

References

Acosta, P. A., E. K. K. Lartey and F. S. Mandelman. 2009. Remittances and the Dutch disease. *Journal of International Economics* **79**: 102-116.

Apergisa Nicholas et al. 2014. Dutch disease effect of oil rents on agriculture value added in Middle East and North African (MENA) countries. *Energy Economics* **45**: 485–490.

Arai Y., Kurozumi E. 2007. Testing for the null hypothesis of cointegration with a structural break. *Econometric Reviews* **26**: 705–739.

Arzac, Enrique R. and Maurice Wilkinson. 1979. A quarterly econometric model of United States livestock and feed grain markets and some of its policy Implications. *Am. J. Ari. Econ.* 61(2):297-308.

Baek, Jungho et al. 2009. Exchange rate dynamics and the bilateral trade balance: the case of U.S. agriculture. *Agriculture and Resource Economics Review* **38(2):** 213-228.

Baek, Jungho et al. 2009. Exchange rate dynamics and the bilateral trade balance: the case of U.S. agriculture. *Agriculture and Resource Economics Review* **38(2):** 213-228.

Banerjee, A., J.J. Dolado, and R. Mestre. 1998. Error-correction mechanism tests for cointegration in a single-equation framework. *Journal of Time Series Analysis* **19(3):** 267-283.

Batchuluun, Amrita and Joung Yol Lin. 2010. An analysis of mining sector economics in Mongolia. *Global Journal of Business Research* **4**: 81-93.

Belasco, Eric J. 2013. The Spatio-temporal Impact of Drought on Local and Regional Feeder Cattle Inventories. Paper presented at the Agricultural & Applied Economics Association’s 2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4-6.

Chavas, J.P. and R.M. Klemme. 1986. Aggregate milk supply response and investment behavior on U.S. dairy farms. *American Journal of Agricultural Economics*. 68: 55-56.

Chen, Huiping, Laping Wu and Yubin Wang. 2010. “The Effect of Subsidy Policy on Chinese Grain Production—Based on Province-Level Data 2004-2007.” *Journal of Agrotechnical Economics (China)* 4: 100-6.

Cheng, Guoqiang. 2005. “Seek Advantages and Avoid Disadvantages for Grain Imports.” *Agriculture Market Weekly* 16: 29.

Chibwana, Christopher, Monica Fisher and Gerald Shively. 2012. “Cropland Allocation Effects of Agricultural Input Subsidies in Malawi.” *World Development* 1: 124–33.

Commodities in China.” *China Economic Review* 18: 155-69.

Corden, W. M. 1984. Booming sector and Dutch disease economics: survey and consolidation. *Oxford Economic Papers* **36(3)**: 359-380.

Corden, W. M. and Neary, J. Peter. 1982. Booming sector and de-industrialization in a small open economy. *The Economic Journal* **92(368**): 825-848.

Cuddington, John T. and Dagher, Leila. 2014. Estimating Short and Long-Run Demand Elasticities: A Primer with Energy-Sector Applications. *The Energy Journal* 36(1):185-209.

Davaakuu, O., K. Sharma, and Y. Baandara. 2014. Export performance during economic transition in Mongolia. *Economic Analyiss and Policy* 44: 442-450.

Dülgera, Fikret et al. 2013. Is Russia suffering from Dutch Disease? Cointegration with structural break. *Resources Policy* **4**: 605–612.

Ebrahim-zadeh, Christine. 2003. Back to basics—Dutch disease: too much wealth managed unwisely. *Finance and Development, A quarterly magazine of the IMF 40 (1)*

Engle, R.F and C.W.J. Granger. 1987. Cointegration and error correction representation: estimation and testing. *Econometrica* **55**: 251-276.

Fielding, D. and Gibson, F. 2013. Aid and Dutch Disease in Sub-Sahara Africa. *Journal of*

African Economies **22**: 1-21.

Gale, H.F., Bryan,L. and Tuan, F.C. 2005. "China's New Farm Subsidies." Electronic Outlook Report from the Economic Research Service, United States Department of Agriculture, February. USDA-ERS WRS-05-01. Available at SSRN: http://ssrn.com/abstract=759444.

Gao, X. M., E. J. Wailes and G. L. Cramer. 1996. "A Two-state Rural Household Demand Analysis: Microdata Evidence from Jiangsu Province, China." *American Journal of Agricultural Economics* 78: 604−13.

Glytsos Nicholas P. 2005. The contribution of remittances to growth A dynamic approach and empirical analysis. *Journal of Economic Studies* **32**: 468 – 496.

Gregory A.W., Hansen B.E.1996a. Residual-based tests for cointegration in models with regime shifts. *Journal of Econometrics* **1**: 99–126.

Gregory A.W., Hansen B.E.1996b. Tests for the cointegration in models with regime and trend shifts. *Oxford Bulletin of Economics and Statistics* **58**: 555–560.

Guyomard, Herve, Chantal Le Mouel and Alexandre Gohin. 2004. "Impact of Alternative Agricultural Income Support Schemes on Multiple Policy Goals." *European Review of Agriculture Economics* 31(2):125-48.

Halbrendt, C., F. Tuan, C. Gempesaw and D. D. Etz. 1994. "Rural Chinese Food Consumption: the Case of Guangdong." *American Journal of Agricultural Economics* 76: 794−99.

Han, J., Y. Zhang, C. Wang, W. Bai, Y. Wang, G. Han, and L. Li. 2008. Rangeland degradation and restoration management in China. *The Rangeland Journal* 30: 233–39.

Hansen, Jim, Francis Tuan and Agapi Somwaru. 2011. "Do China's Agricultural Policies Matter for World Commodity Markets?" *China Agricultural Economic Review* 1: 6-25.

He, Zhongwei. 2006. “Study on Performance and Advance of Food Subsidy Policy in China.” *Science and Technology Review* 4:71-75.

Hedley, Douglas D. and Steven R. Tabor. 1989. “Fertilizer in Indonesian Agriculture: the Subsidy Issue.” *Agricultural Economics* 3:49-68.

Hsu, H. H., W. S. Chern and F. Gale. 2002. How will rising income affect the structure of food demand? China's food and agriculture: Issues for the 21st century/AIB-775 (pp. 10−13). Washington, D.C., USA: ERS/USDA.

Huang, Delin, Xiangyang Li and Songfeng Cai. 2010. “Impact of Agricultural Subsidies on Chinese Food Security Based on China Agricultural CGE Model.” *Chinese Agricultural Science Bulletin* 24:429-35.

Huang, Jikun, Xiaobing Wang, Huayong Zhi, Zhurong Huang and Scott Rozelle. 2011. “The Effect of Direct Subsidy for Grain and Comprehensive Subsidy for Means of Agricultural Production on Agricultural Production.” *Journal of Agrotechnical Economics* 1: 6-14.

Huang, Jikun, Xiaobing Wang, Huayong Zhi, Zhurong Huang and Scott Rozelle. 2011. “Subsidies and Distortions in Chinas Agriculture: Evidence from Producer-Level Data.” *Australian Journal of Agricultural and Resource Economics* 55: 53-71.

Jarvis, L. S. 1974. Cattle as capital goods and ranchers as portfolio managers: an application to the argentine cattle sector. *Journal of Political Economy* 82:489-520.

Johansen, S. 1995. *Likelihood-based inference in cointegrated vector autoregressive models*. Oxford, England: Oxford University Press.

Ke, Bingsheng. 2007. “Chinese Grain Self-sufficiency Rate and Grain Trade Issues.” *Agriculture Prospective* 4: 3-6.

Kremers, J.J.M, N.R. Ericson, J.J. Dolado. 1992. The power of cointegration tests. *Oxford*

Bulletin of Economics and Statistics 54(3): 325-348.

Li, Peng and Xiangyong Tan. 2006. “The Effect of the Direct Grain Subsidy on Farmers’ Revenue—Evidence from Anhui Province.” *Journal of Agrotechnical Economics* 1: 44-48.

Li, Ruifeng and Haifeng Xiao. 2006. “The Effects, Problems, and Improvement of the Direct Grain Subsidy.” *Research of Agricultural Modernization* 27: 92-5.

Li, Yinpeng and Jingjun Ji. 2004. Assessment of the productivity and livestock carrying capacity of Inner Mongolia grassland by regional scale modeling. *Journal of Natural Resources*. 19(5): 610-16.

Li, Zhongfeng and Yunlong Cai. 2007. “Analysis of China’s Food Grain Problem.” *Journal of Anhui Agri .Sci* . 35(31) :10123 –25.

Liu, Han. 2011. “Thinking of Increasing Comprehensive Grain Production Capacity Policy.” *Journal of Agriculture* 10: 55-58.

Liu, K.E. and W.S. Chern. 2001. “Food demand in Urban China and its Implications for Agricultural Trade.” Department of Agricultural, Environmental, and Development Economics, the Ohio State University. http://www.china.wsu.edu/pubs/pdf-2001/7_KLiu.pdf

Lu, Wencong, Huibo Qi and Yuanlong Li. 2011. “The Tendency of China’s Grain Supply and Demand under Globalization.” *Journal of Zhejiang University (Humanities and Social Sciences)* 1: 5-18.

Ma, Aihui and Anlu Zhang. 2012. “Assessment and Optimization of the Agricultural Subsidy Policy.” *Journal of Huazhong Agricultural University (Social Sciences Edition)* 3: 33-37.

Markowitz, M. L. 2013. Agriculture and the food system: a short history and country case study in Mongolia. Capstone Collection Paper 2611. Leicester, UK: University of Leicester.

Melton, B.E. 1980. Economics of beef cow culling and replacement decisions under genetic progress. *Western Journal of Agricultural Economics*. 5(2):137-47.

Narayan, P. K. 2005. The saving and investment nexus for China: evidence from cointegration tests. *Applied Economics* 37: 1979-1990.

Pegg Scott. 2010. Is there a Dutch disease in Botswana? *Resources Policy* **35**:14-19.

Pesaran, M. H. and Y. Shin. 1999. An autogressive distributed lag modeling approach to cointegration analysis. In S. Strom (ed.) *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*. Cambridge, UK: Cambridge University Press, pp. 371-413.

Pesaran, M. H. et al. 1997. Pooled estimation of long-run relationships in dynamic heterogeneous panels. PP. 1-32. University of Cambridge, Department of Applied Economics.

Pesaran, M. H., Y. Shin, and R. J. Smith. 2001. Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics* **16**:289-326.

Razack, Abdul, Stephen Devadoss and David Holland. 2009. “A General Equilibrium Analysis of Production Subsidy in a Harris-Todaro Developing Economy: an Application to India.” *Applied Economics* 41: 2767–77.

Richardson, J. W., K. D. Schumann, and P. A. Feldman. 2008. SIMETAR: Simulation & Econometrics to Analyze Risk. College Station: Texas A&M University.

Rozelle, S., and J. K. Huang. 2000. “Transition, Development, and the Supply of Wheat in China.” *Australian Journal of Agricultural and Resource Economics* 44: 543−71.

Rucker, R. R., O.R. Burt and J.T. LaFrance. 1984. An econometric model cattle inventories. American Journal of Agricultural Economics. 66: 131-44.

Schmitz, John D. 1997. Dynamics of beef cow herd size: an inventory approach. *American Journal of Agricultural Economics* 79: 532-42.

Sun, C. and Kinnucan, H.W. 2001. "Economic Impact of Environmental Regulations on Souther Softwood Stumpage Markets: A Reappraisal." *Southern Journal of Applied Forestry* 25:108-115.

Trapp, J.N. 1986. Investment and disinvestment principles with nonconstant prices and varying firm size applied to beef-breeding herds. *American Journal of Agricultural Economics*. 68: 691-703.

Tryfos, Peter. 1974. Canadian supply functions for livestock and meat. *American Journal of Agricultural Economics*. 56(1):107-13.

van Wijnbergen, S. 1984. The 'Dutch disease': a disease after all? *The Economic Journal* **94**: 41–55.

Wang, Jiao and Haifeng Xiao. 2006. "The Assessment of Chinese Direct Grain Subsidy Policy." *Chinese Rural Economy* 12: 4-13.

Wang, Yuxia and Jihong Ge. 2009. "The Economic Analysis of the efficiency of China's Grain Subsidy." *Guizhou Social Sciences* 3: 71-5.

Wohlgenant, M. K. 2011. "Consumer demand and welfare in equilibrium displacement models." in *The Economics of Food Consumption and Policy* (J. L. Lusk, R. Roosen and J. F. Shogren, editors), pp. 292-317. London: Oxford University Press.

Wu, Cuilian and Wencong Lu. 2011. "The Effect of Food Subsidies on Increasing Grain Production and Income———A Simulation Study Based on the Household Model." *Journal of Jiangxi Agricultural University (China)* 3:60-6.

Wu, Zhihua and Xuejun Hu. 2007. “Synergy between Farmers’ Income and Grain Security.” *Economic Theory and Business Management* 3: 53-6.

Xiao, Guoan. 2005. “The Economic Analysis of the Direct Grain Subsidy.” *Chinese Rural Economics* 3:12-17.

Ye, Hui and Yapeng Wang. 2006. “Grain Direct Subsidy Efficiency and Policy Based on DEA Model.” *Research of Agricultural Modernization* 5: 356-59.

Yu, Wusheng and Hans G. Jensen. 2010. “China's Agricultural Policy Transition: Impacts of Recent Reforms and Future Scenarios.” *Journal of Agricultural Economics*, Wiley Blackwell 61(2): 343-68.

Zeng, Fusheng and Ming Gao. 2011. “An Empirical Analysis on the Price Elasticity ofWheat Import and Export.” *Jounal of South China Agricultural University (Social Science Edition)* 4: 62-68.

Zhan, Jingang. 2009. “The Analysis of the Performance of China’s Grain Subsidy Policy.” *Journal of Hunan Agricultural University (Social Sciences)* 4: 17-21.

Zhao, Hui, Hong Zhang and Shixiong Cao. 2014. “Unexpected Results from China's Agricultural Subsidies Policy.” *Society & Natural Resources: An International Journal* 27(4): 451-57.

Zhong, Yongling and Hui Cao. 2011. “Developmental Status, Regulation Policy and Suggestion of Chinese Wheat Industry.” *Journal of Agriculture* 12:49-54.

Zhu, Bin. 2007. “Future of Chinese Grain Imports.” *Macroeconomic Management* 12: 38-41.

Zhuang, Renan and Philip Abbott. 2007. “Price Elasticities of Key Agricultural