Policy analysis with Melitz-type gravity model: evidence from Kyrgyzstan

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Abstract

Several governments worldwide aim at fostering agricultural productivity growth by providing investment support. However, the policy's effect on trade for middle- and low-income countries has not been analyzed so far. This paper analyzes the impact of agricultural policies (credit subsidies and tariffs) on agricultural trade flows by modifying a Melitz-type structural gravity model for a small and open economy. According to the theory, trade flows are expected to increase with credit subsidies and decrease with partner's applied tariff rates. We analyze bilateral agricultural trade flows between Kyrgyzstan and its 69 trading partners for the period between 2007-2018 to test our theoretical findings. Applying the Poisson pseudo maximum likelihood estimator, we find that credit subsidy policy is ineffective in enhancing international trade flows while trade partners' tariffs imposed on agricultural products reduce Kyrgyzstan's export substantially.

Keywords: gravity model, general equilibrium effects, tariffs, subsidies.

JEL Classification: F10, F13, F14.

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1 Introduction

Previous analyzes on the impact evaluation of agricultural input subsidies covered a broad range of outcome indicators (e.g., Hemming et al., 2018[22]). Many of them are of a microeconometric nature comparing beneficiaries with non-beneficiaries. However, the availability of farm- or household-level data, ideally covering several years, is often a challenge. Furthermore, a focus on household-level effects might fail to consider indirect effects at the level of consumers or international trade which might be substantial as illustrated by Tong et al. (2019)[33] in the case of aggregated US farm subsidies. But the effect of a single input policy instrument cannot be disentangled. Therefore, this study offers an alternative approach to study the economic impact of an input subsidy. More specifically, this study is the first to examine the effect of credit subsidies for agricultural producers on agricultural trade.

Studies on the efficacy of input support policies on trade at the macro level are scarce due to the complexities in calculating the indirect effects of subsidizing inputs. For large economies such as the European Union that provides comprehensive agricultural input subsidies with many instruments, the impact evaluation analysis is almost impossible. However, the analysis becomes feasible for small countries with few agricultural support policies, such as Kyrgyzstan. To analyze multiple instruments at the macro level, we propose a new approach treating credit subsidies as a non-trade and applied tariff rates as a trade policy.

Gravity model, acquiring a range of micro-founded macro theoretical bases, is the most frequently used framework in applied international trade literature (e.g., Wilson et al., 2003[35] Agnosteva et al., 2014[1], Bergstrand et al., 2015[7], Dai et al., 2014[11], Fally, 2015[17], Jarreau, 2015[23]). The policy studies focused on international trade use either an Anderson and van Wincoop (2003)[3] model of perfect competition with homogeneous goods or an Eaton and Kortum (2002)[13] model with sectoral heterogeneity. Both models assume that each firm's productivity is identical before entering the international market. However, Bernard et al. (2007)[8] provided an overview of empirical patterns about firms engaged in international trade and found considerable heterogeneity in a firm's exporting behavior. Before entering the international market, exporting firms tend to be larger, more productive, more skilled, and capital-intensive than non-exporting ones.

A Melitz (2003)[30] model of monopolistic competition with heterogeneous firms captures many empirical facts mentioned by Bernard et al. (2007)[8] and the potential source for gains from trade (e.g., Arkolakis et al., 2012[4]). Although the Melitz (2003)[30] model provides the backbone for many trade papers written in the past decade, a few studies used this framework theoretically (e.g., Eaton et al., 2011[14], Helpman et al., 2010[21]) and empirically (e.g., Bas and Bombarda, 2012[6], Chevassus-Lozza et al., 2011[10], Eaton et al., 2012[15], Helpman et al., 2008[20]). To our best knowledge, no paper addresses the Melitz (2003)[30] model's gravity framework in the context of the agricultural sector of a small economy.

Farm products are consistent with the assumptions of the Melitz framework. Farmers differ in productivity due to their heterogeneity in production technologies resulting in differentiated agricultural commodities. In addition, we assume that the distribution of productivity is Pareto since productivity is related to agricultural land which is usually Pareto distributed (Akhundjanov and Chamberlain 2019[2]). Hence, the present study derives a Melitz-type sectoral gravity equation for a small economy and examines theoretical findings with Poisson pseudo maximum likelihood (PPML) estimator (Silva et al., 2006[32]) using data from Kyrgyzstan.

In 2013, the Kyrgyz government launched the "Financing of Agriculture" project to reduce the country's import dependence on farm products by enhancing farmers' productivity. In particular, it has provided subsidized interest rates on farmers' loans under a series of government programs. Although the government adjusts the credit subsidies annually, no impact evaluation study has been conducted. With this study, we aim to assess the effect of credit subsidies and applied tariff rates on trade flows of farm goods and suggest policy implications for the Kyrgyz government.

The contribution of our work to the existing literature is threefold. First, given the characteristics of the country and the relevance of a Melitz (2003)[30] model, we extend a small and open economy model of Demidova & Rodriguez-Clare (2013)[12] to identify the general equilibrium effects of bilateral trade and unilateral non-trade policies. Second, we examine a Melitz-type structural gravity model using the PPML estimator due to its numerous advantages over other estimators in structural gravity models (Silva et al., 2006[32]). Third, we use cross-country annual panel data to evaluate the impact of agricultural support policies (credit subsidies and applied tariffs) on bilateral trade flows from and to Kyrgyzstan.

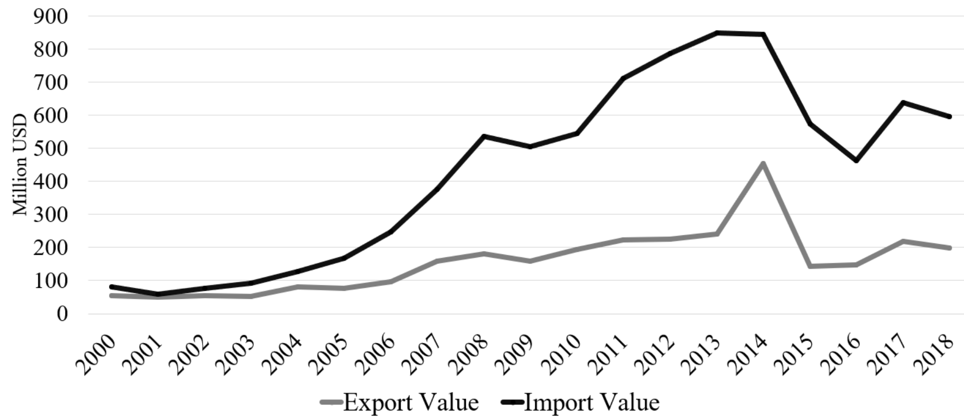
The remainder of the paper is structured as follows. In the next section, we provide a necessary background on agricultural trade in Kyrgyzstan and a summary of agrarian policy regimes. In the third section, we present our theoretical findings. The fourth section presents the empirical analysis with the results. The last section concludes the study.

2 Agricultural Trade in Kyrgyzstan

Kyrgyzstan was an agricultural country during the Soviet period. The population was primarily rural-based on cotton in the south, grain farming in the north, and livestock. Agriculture in Kyrgyzstan is still the primary sector in the country's economy. However, it is no longer "a driver" of economic growth as it was in the second half of the 1990s (Light, 2007[28]). About a quarter of the economically active population in Kyrgyzstan is engaged in agriculture while half of the total population depends on the sector for their livelihood (World Bank, 2020). The share of agriculture in GDP has dropped from 46% in the first decade of transition to about 12% in 2018 (World Bank, 2020).

Kyrgyzstan neighbors Kazakhstan, Uzbekistan, Tajikistan, and China. Although it is land-locked, it is geographically and economically well-positioned for international trade in terms of large markets located nearby. Additionally, Kyrgyzstan was one of the most quickly reforming countries among the former Soviet republics and became the first, apart from the Baltic states, to accede to the World Trade Organization (WTO) in 1998 (Pomfret, 2019[31]). Despite substantial trade policy liberalization at the beginning of the transition, it's export performance was rather disappointing. On the one hand, increased demand for high value-added products driven by lifestyle habits and dietary structure increased the imports of processed food products since 2001. On the other hand, the low competitiveness of the agro-processing sector in terms of technology, product variety, and quality led to a sharp decline in the agro-processing industry's output. Consequently, Kyrgyzstan has become a net importer of agricultural products since 2001 (Figure 1).

Figure 1: **Evolution of Trade in Agricultural Goods, 2000-2018**

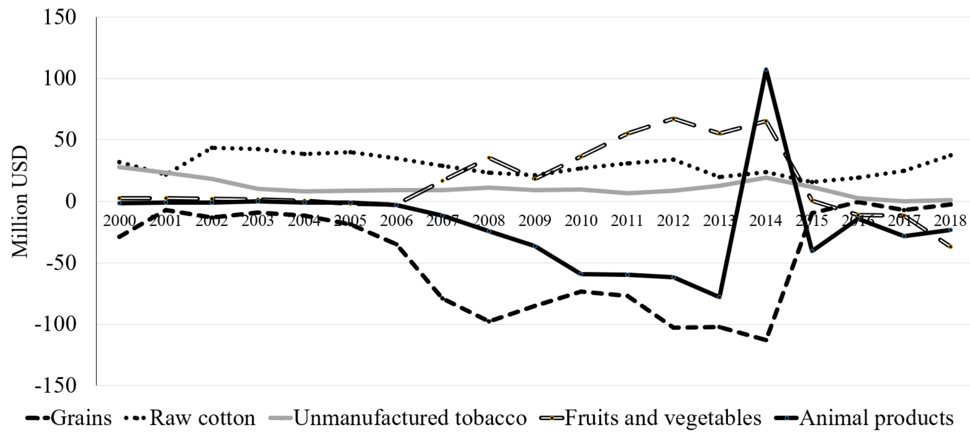


Source: UN COMTRADE 2020, authors' calculations.
With regards to discussions related to trade, all individual products belonging to product groups with 2-digit HTS codes between 01 and 24 are accepted as agricultural goods.

To further evaluate the international trade trend, we look at the net trade of primary five agricultural commodities during 2000-2018. This group of main items includes grains (wheat, maize, barley, rice), raw cotton, unmanufactured tobacco, fruits and vegetables (potatoes, tomatoes, cucumbers, onions, cabbages, carrots, grapes, apples, pears, apricots, cherries, peaches), and animal products (beef, pork, mutton, horse meat, poultry, milk, eggs, wool, and honey). As shown in Figure 2, the composition of exports and imports of all agricultural commodities has changed structurally in the last two decades. Kyrgyzstan has been the fastest-growing net importer in grains and animal products and net exporter in fruits and vegetables during 2000-2014. As of 2014, the trend for all commodities has changed to the opposite. The country started to export more raw materials and import high-value-added products such as fruits and vegetables. One year flash in animal products' structure occurred due to a large amount of exported beef to Kazakhstan in 2014.

After the collapse of the Soviet Union, the Kyrgyz government implemented a series of fundamental changes in the agricultural sector, such as the dismantlement of state farms, the abolition of direct support, agricultural price liberalization, and privatization of land. Among all the reforms, two were successful in increasing farmers' productivity: private ownership and redistribution of

Figure 2: **Evolution of Net Trade in Agricultural Commodities, 2000-2018**



Source: UN COMTRADE 2020, authors' calculations.

land. Other reforms did not increase the farmers' productivity due to weak institutions and poor infrastructure in the agricultural sector. Furthermore, newly created smallholder farms needed support and required farm services adjustments (Lerman et. al., 2009[27]).

On the other hand, implemented reforms and the substantial decline in USSR transfers led to a massive budget deficit (about 17% of GDP). The Kyrgyz government tried to cushion the impact of withdrawn direct support from the USSR through indirect subsidies: tax exemptions from value-added tax, price support for the use of irrigation services, price discount for electricity usage, and vaccinations usually provided by the finance obtained from international aid organizations. And only in 2013, the government implemented the project called "Financing of Agriculture–I-IV" which was extended for additional five years in 2016.

The project aims at providing subsidized interest rates on loans obtained from the government's partner banks. The government compensates banks by paying the difference between the subsidized credit interest rate and the average market interest rate on loans. Hence, farmers pay an interest rate of 10% regardless of the market rate which fluctuates from 22 to 30%. The government has introduced additional requirements related to farmer's occupation and productivity because the total amount of support is limited due to the limited state budget. As a result, small farmers do not have access to subsidized loans.

The structural gap in 2014, when producers switched from growing high value-added products to raw materials such as grain and raw cotton, has not been studied yet. The structural break in 2014, when producers switched from growing high value-added products to raw materials such as grain and raw cotton, has not been studied yet. We need additional microdata to analyze whether this break is related to the farmer support policy or other external factors. However, this break does not affect our results in the study because we take it into account and minimize it with fixed effects.

3 Theoretical Framework

To analyze the effect of credit subsidies and tariff rates on trade in a small and open economy, first, we modify a Demidova & Rodriguez-Clare (2013)[12] model. Specifically, the government levies labor taxes and imposes tariffs on imported agricultural products to provide credit subsidies to farmers in our model. Second, we derive general equilibrium effects and the Melitz-type structural gravity equation. Then, we provide comparative statics analysis according to our focus variables.

3.1 Demand

We consider the origin country as i and the destination country as j where i can be treated as a small economy. Countries are populated by identical households where each inelastically supplies one labor unit and earns wage w. Consumers spend their income on domestic and imported varieties of differentiated goods. Additionally, consumers are assumed to have CES-type utility functions over a continuum of goods indexed by $\omega \in \Omega$ with an elasticity of substitution $\sigma > 1$.

Optimal demand in country j for domestic variety is

$$q_{ij}(\omega) = p_{ij}(\omega)^{-\sigma} Y_j P_j^{\sigma-1} \tag{1}$$

where $p_{ij}(\omega)$ denotes the the price of the good produced in i and sold in j. Y_j indicates the aggregate expenditure of country j. $P_j \equiv \left(\sum_i \int_{\omega \in \Omega_i} p_{ij}(\omega)^{1-\sigma} d\omega\right)^{\frac{1}{1-\sigma}}$ stands for the price index in country j. In line with a small and open economy assumption, demand for foreign variety is given by $q_{ji}(\omega) = Ap_{ji}(\omega)^{-\sigma}$ where A includes both national income and the price index in the origin country.

3.2 Supply

In each country, a differentiated variety is produced by a different producer where M_i denotes the mass of the monopolistically competitive firms in the origin country. Labor is the only factor of production. Firms pay a fixed cost $w_i f_i^e$ to enter the market; after that, they draw their random productivity φ which is sampled from a Pareto distribution with a cumulative distribution function[1] given by $G_i(\varphi)$. Knowing φ, the domestic market-oriented producer in country i faces variable costs $\frac{w_i}{\varphi}$ while the export-oriented producer must additionally pay tariffs $(1+\kappa_{ij})$ imposed on imported goods by the destination country j and fixed market access cost $w_i f_{ij}$. Moreover, producers in the small country face liquidity constraints in financing their production costs. More precisely, firms borrow their production cost in advance at a market interest rate $r_i \in (0,1)$ which is exogenously given[2]. However, they receive a credit subsidy $s_i \in [0, r_i]$ on the market interest rate r_i. Accordingly, the net interest rate $(r_i - s_i)$ should matter for producers. Credit subsidies are provided on funds collected from labor taxes at a constant rate $\gamma_i \in (0,1)$ by the government. As usual, we assume that there are iceberg transport costs $\tau_{ij} = \tau_{ji} \geq 1$, where $\tau_{ii} = 1$.

Given demand (Eq.1), tax, interest and subsidy rates the price charged by the firm from i conditional on selling to destination j is

$$p_{ij}(\varphi) = \frac{\sigma}{\sigma - 1}\frac{w_i}{\varphi}(1+\kappa_{ij})\tau_{ij}\,(1 + r_i - s_i). \tag{2}$$

[1]Our parametrization of the productivity function based on Chaney (2008)[9]. According to his assumption, productivity φ is distributed Pareto with lower bound $\varphi_{\min} = 1$ and shape parameter $\theta_i > \sigma - 1$. The cumulative distribution function is $G_i(\varphi) = 1 - \varphi^{-\theta_i}$ and the probability density function is given by $g_i(\varphi) = \theta_i \varphi^{-\theta_i - 1}$.

[2]Foreign lenders do not affect the welfare of the origin country. Consequently, we assume that interest rates are not affected by firms in the model.

3.3 Government

The government taxes labor income on a lump-sum basis and imposes tariff rates on imported goods to subsidize loans to producers. The planner's budget is balanced in every period. Then, the government budget constraint is given by

$$S_i \equiv \frac{M_i s_i q_{ij}(\varphi)}{\varphi} = w_i L_i \gamma_i + M_j q_{ji}(\varphi)\kappa_i, \tag{3}$$

where $\frac{M_i s_i q_{ij}(\varphi)}{\varphi}$ is the amount of the total loans subsidized by the government and it is the only source of the government spending S_i. The total income of the government i consists of labor taxes $w_i L_i \gamma_i$ and income from imposed tariffs $M_j q_{ji}(\varphi)\kappa_i$.

3.4 Equilibrium

General equilibrium for this model is defined as follows.

Definition 1. *An equilibrium of this economy is a set of quantities* $\{q^*_{ij}(\varphi)\}$*, prices* $\{p^*_{ij}(\varphi), w^*\}$*, and exogenous government policies* $\{s^*_i, \gamma^*_i, r^*_i, \kappa^*_i\}$*, such that*

1. *given* $\{p^*_{ij}(\varphi), w^*, \gamma^*_i, r^*_i\}$*, the representative consumer chooses the optimal quantities to maximize the consumer's utility in a budget-constrained environment;*

2. *given* $\{s^*_i, w^*, r^*_i, \kappa^*_i\}$*, the representative producer chooses the optimal prices to maximize the producer's profit at the optimal demand;*

and the following conditions hold:

i. *zero cutoff profit condition;*

ii. *free entry condition;*

iii. *labor market clearing condition;*

iv. *trade balance condition;*

v. *income spending equality condition.*

The *zero cutoff profit condition (ZCP)* requires the firm to earn non-negative profits and engage in export if and only if $\Pi_{ij}(\varphi) \geq 0$. Among the producers in country i, only the most productive ones with $\varphi_{ij} \geq \varphi^*_{ij}$ sell in the market j.

The *free entry condition (FE)* for firms in country i equalizes the expected profit on market entry with the entry cost, $E_\varphi \left[\sum_j \max\left\{\Pi_{ij}(\varphi), 0\right\}\right] = w_i f^e_i$.

The *labor market clearing condition (LMC)* equalizes total labor demand to labor supply in the country i which is given as

$$M^e_i w_i f^e_i + M_i \int\limits_{\varphi^*_{ij}}^{\infty} \left(q_{ij}(\varphi)\tau_{ij}\frac{(1 + r_i - s_i)(1 + \kappa_{ij})}{\varphi} + w_i f_{ij}\right) \frac{dG_i(\varphi)}{1 - dG_i(\varphi^*_{ij})} = L_i(1 - \gamma_i) \qquad (4)$$

where M^e_i and L_i denote the mass of entrants and the number of identical households in the origin country, respectively.

The *trade balance condition (TB)* requires the origin country's aggregate imports from the destination country to be equal to its aggregate exports to the destination country, $X_{ij} = X_{ji}$.

The final equilibrium condition, stating that the total income should be equal to the total spending of the country i automatically holds by Walras' Law.

To summarize[3], equilibrium consists of four ZCPs, two FEs, and two LMCs, making up a system of eight equations in eight unknown endogenous variables: $\varphi^*_{ii}, \varphi^*_{jj}, \varphi^*_{ij}, \varphi^*_{ji}, M_i, M_j, w_i, w_j$.

3.5 Bilateral Trade

To generate a gravity equation, we need to aggregate total trade flows across all firms in the origin country which requires aggregate variables of prices and productivity. Hence, average price charged by all firms in i selling to j is $\int_{\Omega_i} p_{ij}(\varphi)^{1-\sigma} d\varphi = \int_0^\infty M_{ij} p_{ij}(\varphi)^{1-\sigma}\mu_{ij}(\varphi) d\varphi$ where M_{ij} is the mass of firms exporting from i to j and $\mu_{ij}(\varphi)$ is the probability density function of firms' productivities from country i that sell to country j. Average productivity of exporters can be defined as $\tilde{\varphi}_{ij} \equiv (\int_0^\infty \varphi^{\sigma-1}\mu_{ij}(\varphi)d\varphi)^{\frac{1}{\sigma-1}}$.

[3] Detailed derivation of every condition can be presented upon request.

These considerations allow us to write the gravity equation implicitly as

$$X_{ij} = \left(\frac{\frac{\sigma}{\sigma-1} w_i (1 + r_i - s_i) \tau_{ij} (1 + \kappa_{ij})}{\tilde{\varphi}_{ij} P_j} \right)^{1-\sigma} M_{ij} Y_j \tag{5}$$

where

$$\tilde{\varphi}_{ij} = \left(\frac{M_i}{M_{ij}} \frac{\theta_i}{1-\sigma+\theta_i} \left(\frac{\sigma}{\sigma-1} \frac{(1+\kappa_{ij})\tau_{ij}(1+r_i-s_i)w_i}{P_j} \right)^{\sigma-1-\theta_i} \left(\frac{\sigma f_{ij}}{Y_j} \right)^{\frac{\sigma-1-\theta_i}{\sigma-1}} \right)^{\frac{1}{\sigma-1}}.$$

Eq.5 provides the same sectoral gravity equation due to the separability of the structural gravity theory demonstrated by Anderson & van Wincoop (2003)[3]. Explicit derivation of the sectoral gravity equation (Eq.5) yields

$$X_{ij} = \frac{Y_i^{\frac{\theta_i}{\sigma-1}} Y_j^{\frac{\theta_i}{\sigma-1}}}{\sum_j Y_j^{\frac{\theta_i}{\sigma-1}}} \left(\frac{\tau_{ij}(1+\kappa_{ij})}{P_j \Pi_i} \right)^{-\theta_i} f_{ij}^{\frac{\sigma-1-\theta_i}{\sigma-1}}. \tag{6}$$

The terms $P_j = \sum_i \left(\frac{\tau_{ij}(1+\kappa_{ij})}{\Pi_i} \right)^{-\theta_i} \frac{Y_i^{\frac{\theta_i}{\sigma-1}}}{\sum_j Y_j^{\frac{\theta_i}{\sigma-1}}} f_{ij}^{\frac{\sigma-1-\theta_i}{\sigma-1}}$ and $\Pi_i \equiv \sum_j \left(\frac{\tau_{ij}(1+\kappa_{ij})}{P_j} \right)^{-\theta_i} \frac{Y_j^{\frac{\theta_i}{\sigma-1}}}{\sum_j Y_j^{\frac{\theta_i}{\sigma-1}}} f_{ij}^{\frac{\sigma-1-\theta_i}{\sigma-1}}$ are respectively called inward and outward multilateral resistance terms that account for third-country effect in determining bilateral trade flows (Anderson & van Wincoop 2003)[3]).

We take the first-order derivatives of X_{ij} with respect to s_i and κ_{ij} to find the relationship between agricultural policies and trade flows of agricultural goods:

$$\frac{\partial X_{ij}}{\partial s_i} = C \frac{\theta_i}{(1+r_i-s_i)^{1+\theta_i}} (1+\kappa_{ij})^{-\theta_i} > 0, \tag{5.1}$$

$$\frac{\partial X_{ij}}{\partial \kappa_{ij}} = -C \frac{\theta_i}{(1+\kappa_{ij})^{1+\theta_i}} (1+r_i-s_i)^{-\theta_i} < 0, \tag{5.2}$$

where $C \equiv \sigma^{\frac{\sigma-1-\theta_i}{\sigma-1}} \left(\frac{\sigma-1}{\sigma}\right)^{\theta_i} \left(\frac{\theta_i}{1-\sigma+\theta_i}\right) \left(\frac{P_j}{\tau_{ij} w_i}\right)^{\theta_i} Y_j^{\frac{\theta_i}{\sigma-1}} M_i f_{ij}^{\frac{\sigma-1-\theta_i}{\sigma-1}}$.

Two hypotheses are proposed for bilateral trade and unilateral non-trade agricultural policies based on the comparative statics analysis in Eq.5.1 and Eq.5.2:

Hypothesis 1. *Trade flows increase as the amount of credit subsidies increases (based on Eq.5.1).*

Hypothesis 2. *Trade flows decrease as the applied tariff rates increase (based on Eq.5.2).*

Melitz's (2003)[30] heterogeneous firm model is more sensitive to changes in trade costs than Krugman's (1980)[25] model of homogeneous firms due to the $\theta_i > \sigma - 1$ assumption. Furthermore, it predicts larger responses in trade flows by intensive (exporting firms export more) and extensive (smaller firms start to export) margins, while Krugman (1980)[25] model lacks the second effect. To capture all effects (multilateral resistances, intensive and extensive margins), we estimate Eq.5 applying it to Kyrgyzstan's agricultural sector. Although no data exist about the number of exporting farmers (which clearly shows the extensive margin of trade policies) we provide a descriptive analysis of new destinations of trade flows.

4 Empirical Evidence

We aim to analyze Kyrgyzstan's international trade flows (export and import) for its 69 trading partners using the structural gravity model in a more specific way. We provide an econometric panel data estimation of the earlier derived theoretical concept (Eq.5) defining Kyrgyzstan as a single-origin country.

4.1 Specification

We follow Yotov et al., (2016)[36] guide for estimation purposes. They propose a comprehensive and theoretically-consistent gravity specification that identifies bilateral and unilateral non-discriminatory trade policy effects. Despite the lack of data on fixed costs and the number of exporters, we include all other Melitz framework's main variables. Hence, our empirical analysis consists the estimation of the following gravity equation:

$$X_{ij,t} = \exp\left[\beta_1 \ln S_{i,t} + \beta_2 I_{ij,t} \times \ln S_{i,t} + \beta_3 \ln S_{i,t-2} + \beta_4 \ln T_{ij,t} + \beta_5 \ln V_{ij,t} \right.$$
$$\left. + \beta_6 \ln Y_{j,t} + \beta_7 \ln D_{ij,t} + \beta_8 P_{j,t} + \pi_{i,t} + \chi_{j,t} + \lambda_{i,j}\right] \varepsilon_{ij,t}. \tag{7}$$

Eq.7 describes the relation between nominal trade flows ($X_{ij,t}$) at time t and the following explanatory variables where $S_{i,t}$ refers to the total amount of credit subsidies provided by the Kyrgyz government. $I_{ij,t}$ is a dummy variable which takes a value of 1 if Kyrgyzstan is an importer; 0 otherwise. We put an interaction term in our specification to separate credit subsidies' effect on imports because the import substitution effect can stimulate expansion in production. Also, we include two years lagged subsidies $S_{i,t-2}$ to evaluate the phasing-in effects of implemented policy (i.e. agricultural production responding to investments]. $T_{ij,t} = (1 + \kappa_{ij,t})$ denotes applied agricultural bilateral tariff rates where we use applied most-favored-nations (MFN) tariffs for those countries Kyrgyzstan does not have any trade agreement. $V_{ij,t}$ represents the average productivity of farmers while $Y_{j,t}$ indicates the production of agricultural goods of destination country. D_{ij} shows the weighted distance between Kyrgyzstan and its trading partners (proxy for transportation costs) and $P_{j,t}$ represents an import price index. $\pi_{i,t}$, $\chi_{j,t}$ and $\lambda_{i,j}$ indicate the time-varying exporter-importer fixed effects and pair fixed effects, respectively. $\varepsilon_{ij,t}$ is the multiplicative error term. Our focus is on the sign of the estimated coefficients of $S_{i,t}$ and $T_{ij,t}$ in this specification. According to our theoretical analysis, we expect the sign of credit subsidies to be positive since a larger amount of subsidies implemented by Kyrgyzstan accelerates the productivity of farmers which in turn affects trade flows positively (Vatn, 2002[34]). In contrast, an increase in tariff rates imposed by importers is associated with a small amount of trade flows for Kyrgyzstan and vice-versa. Hence, we expect the sign of tariffs to be negative.

4.2 Data

Our dataset is a balanced annual cross-country data for Kyrgyzstan and its 69 trading partners[4], consisting of exports and imports during 2007-2018 with 1,656 observations. We used the United Nations COMTRADE database for data on international trade flows[5]. The data on agricul-

[4]Trade partners include Afghanistan, Albania, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Belarus, Belgium, Bosnia Herzegovina, Bulgaria, Canada, China, Hong Kong, Croatia, Czechia, Denmark, Egypt, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, South Korea, Kuwait, Latvia, Lebanon, Lithuania, Malaysia, Mexico, Moldova, Mongolia, Montenegro, Netherlands, Macedonia, Norway, Oman, Pakistan, Philippines, Poland, Qatar, Romania, Russia, Saudi Arabia, Serbia, Singapore, Slovenia, Spain, Switzerland, Tajikistan, Thailand, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uzbekistan, Viet Nam.

[5]The data was collected by the definition of agricultural products, grouped under the eight-digit Harmonized System 2007 nomenclature, in the WTO annual publications.

tural credit subsidies,[6] as exporter's non-trade policy data, collected from the Ministry of Finance database of the Kyrgyz Republic. The data on weighted tariffs, as importer's non-discriminatory trade policy data, was calculated according to WTO's manual by Bachetta et al., (2012)[5] using trade and tariff rates from WTO's annual publications called "World Tariff Profiles". We also used other sources for standard gravity variables like the United Nations Statistics Divisions database for data on gross value added (GVA), the International Monetary Fund database for consumer price indices, and the GeoDist database on CEPII measured by Mayer & Zignago (2011)[29] for weighted international bilateral distances. We calculate the average productivity data[7] using GVA and employment in agricultural sector. The data on total labor force in the agricultural sector are sourced from the World Bank's World Development Indicators (WDI).

Table 1 provides descriptive statistics of all variables used in the empirical analysis.

Table 1: **Complete Dataset Summary Statistics**

	Mean	Std. Dev.	Min.	Max.
Trade (million USD)	6.02	25.70	0.00	262.00
Subsidy (million USD)	2.34	4.25	0.00	13.70
Weighted tariff (%)	9.14	30.98	0.00	844.50
Productivity (thousand USD)	17.35	108.90	0.55	2976.43
Nominal GVA (billion USD)	16.70	74.50	0.06	1020.00
Weighted distance (thousand km)	4.51	2.56	0.54	15.96
CPI (%)	116.94	32.83	63.01	508.02

4.3 Methodology

We follow Silva & Tenreyro (2006)[32] to estimate our theoretical model with the PPML estimator[8] since our gravity model is in multiplicative form and it has a number of advantages over other estimators. First, it accounts for heteroscedasticity. Second, the PPML estimator can use information containing zeros in trade flows while other log-linear estimators exclude them. Third, it is consistent in the presence of fixed effects as in simple OLS. Fourth, the PPML can also be used

[6] Credits are provided by the following interest rates: livestock - 10%, crop - 10%, processing - 8%.

[7] Average productivity of farmers is calculated as follows: Prod=GVA/labour force in the agricultural sector.

[8] Stata contains a built-in *ppml* command developed by Santos Silva & Tenreyro (2006)[32] that can easily be applied to the gravity model.

to calculate theory-consistent general equilibrium effects of trade policies (Larch et. al., 2016[26]). Finally, the interpretation of the PPML estimator's coefficients is straightforward and follows the same pattern as in OLS. However, we also display estimates using the OLS estimator to show the robustness of our analysis.

We provide five different estimations to see the effects of gravity variables and multilateral resistance terms on trade flows by applying other methods. Loglinearizing our econometric model, first, we perform pooled OLS and fixed effects OLS estimation techniques. However, these estimators do not control for heteroscedasticity where our data exhibits a large degree of heteroscedasticity. Furthermore, fixed effects OLS only partially controls for the multilateral resistances while pooled OLS doesn't at all.

Second, we provide the PPML estimator with exporter and importer time fixed effects without counting potential endogeneity issues of focus variables. The fourth regression includes directional country-pair fixed effects to the PPML estimator to obtain consistent gravity estimates. We further modified the fourth regression in Column 4, including two years lagged subsidy variable, to capture the impact of subsidy policy changed over time. Even more important, there might be a time lag between the uptake of the credit subsidy by a farmer and the resulting (expected) increase in production. Therefore, we focus on the last estimator where we take into consideration all before mentioned econometric issues except serial correlation and cross-sectional interdependence. Our data do not suffer from serial correlation. In contrast, we faced cross-sectional interdependence which may cause bias in the nonzero correlation between factors and regressors (Kapetanios et. al., 2017[24]). Such multi-dimensional models call for new econometric methods to deal with this issue which are not readily developed.

4.4 Results and Discussion

We present the parameter estimation results for our gravity model's determinants in Table 2. Econometric specifications deliver relatively low fit with an R-square ranging from 21% to 33%. However, a high R-square does not necessarily indicate the models' goodness of fit because adding a predictor to a model increases R-square. Overall, the estimates for the gravity equation's "conventional" variables align with previous studies in the literature establishing the sample's representativeness. By comparing different specifications, our results remain stable and the coefficients do not differ markedly in terms of magnitude, which shows the robustness of our analysis[9].

Table 2: **On the Impact of Subsidies and Tariffs on International Trade**

	(1) OLS	(2) OLS	(3) PPML	(4) PPML	(5) PPML
Log credit subsidy	-0.016	-0.022	0.001	0.006	-0.005
	(0.010)	(0.054)	(0.027)	(0.027)	(0.026)
Importer × log credit subsidy	0.043	-0.006	0.123	0.079	0.075
	(0.029)	(0.107)	(0.074)	(0.074)	(0.067)
Lagged log credit subsidy(t-2)					-0.027
					(0.024)
Log weighted tariffs	-0.414***	-0.703***	-0.723***	-0.987***	-1.054***
	(0.081)	(0.133)	(0.109)	(0.103)	(0.109)
Log average productivity	0.401***	0.254**	0.267***	0.013	0.022
	(0.078)	(0.078)	(0.055)	(0.046)	(0.050)
Log gross value added	0.525***	0.483***	0.567***	0.0.458***	0.467***
	(0.058)	(0.052)	(0.049)	(0.046)	(0.049)
Log distance	-1.741***	-1.046***	-0.863***		
	(0.140)	(0.194)	(0.113)	(0.109)	(0.121)
Consumer price index	0.002	0.004	0.000	-0.000	-0.000
	(0.002)	(0.003)	(0.001)	(0.001)	(0.001)
Constant	12.937***	9.487***	2.651	0.888	0.417
	(1.467)	(1.483)	(1.358)	(1.239)	(1.304)
R-squared	0.242	0.224	0.213	0.303	0.330
Observations	1322	1322	1308	1308	1116
Exporter-time fixed effects	No	Yes	Yes	Yes	Yes
Importer-time fixed effects	No	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	No	No	Yes	Yes

Notes: Column (1) applies pooled OLS estimator and column (2) uses the OLS fixed effects estimator. Therefore, dependent variables for these estimators have logged variables of bilateral trade flows. Column (3), (4), and (5) employ the PPML estimator. Column (4) adds directional country-pair fixed effects and column (5) introduces two years of lagged credit subsidy to the previous column. The estimates for the fixed effects and the pair fixed effects are omitted for brevity. Standard errors are robust and are reported in parentheses. *, **, *** denote 1, 5 and 10% confidence levels, respectively.

The empirical results summarized in Table 2 show that the Kyrgyz government's credit subsidies as a unilateral non-trade policy fail to support our theory as we cannot reject the Null hypothesis. Possible reasons for this outcome could be the following. First, the amount of subsidies is too small

[9] The total number of observations is 1656. Some of the observations are omitted due to time and pair fixed effects in the PPML estimations.

compared to agriculture's GVA. For instance, the share of credit subsidies increased from 0.93% of GVA in 2013 to 1.17% in 2018, but it is still like adding a drop to the sea.

Second, this policy could affect small farmers whose production is focused only on the domestic market. A rise in domestic farmers' productivity reduces agricultural products' import substitution due to the fixed demand for agricultural goods in the country. However, the share of the labor force in agriculture to the total labor force in Kyrgyzstan decreased from 53.08% to 26.52% in the last two decades. Hence, subsidies could increase domestic farmers' productivity, but the demand for imported agricultural products could also increase due to the supply shortage of farm goods in the domestic market. To examine the impact of credit subsidies on the international trade of exporters and importers separately, we need disaggregated data on the production, labor, and production costs of exporters and importers, which could be the subject of future research.

Last but not least, these subsidies can be used for purposes other than intended ones. Banks need to provide more loans than to monitor their efficiency. Farmers could use this opportunity for other consumption purposes like festive events characteristic for the Central Asian people. Over the years, their popularity has grown, increasing their expenses, thus forcing people to spend credit subsidies for other purposes. Which of these effects could serve as explanation requires more data, including micro-level observations from beneficiaries.

We find a statistically insignificant relation between interaction term and import which confirms that the impact of a supply shortage of agricultural goods dominates the indirect effect of credit subsidies on importers. Furthermore, the shift of domestic production from high-value-added crops to raw materials in 2014 could also enhance the demand for imported high-value-added crops. Consequently, this policy does not influence importers' trade decisions due to the increasing demand for imported goods in Kyrgyzstan.

Any investment needs time to result in a higher output. However, the estimated coefficient of two years lagged subsidy variable points to strong but statistically insignificant phasing-in effects. In particular, the relatively small average effect of credit subsidies over the first two years after its implementation decreases more than five times. The four-year lagged subsidy variable[10] shows an

[10] We dropped from the regression for non-entanglement.

insignificant but positive coefficient suggesting a non-monotonic relationship between trade flows and credit subsidies. That being said, the effects of subsidies remain insignificant even four years after their implementation.

The applied tariff rates as a bilateral trade policy implemented by the importers show statistically significant negative estimates consistent with theory and confirm the existing literature on the importance of international trade tariffs (Emlinger et. al., 2008[16], Heid et. al., 2017[19]). Moreover, the coefficients are lower for those estimates where we control the multilateral resistances with directional (exporter and importer) fixed effects. In our theoretical framework, the beta coefficient of applied tariffs is equal to $\beta_4 = -\theta_i$ where the estimates of trade elasticity of substitution (σ) vary between 2 and 12 in the existing literature.[11] Hence, our beta coefficients obtained from all specifications are within these boundaries except PPML estimation with pair-fixed effects. The beta coefficient of tariffs in PPMLE with pair-fixed effects can be slightly lower when σ takes a lower bound value, $\sigma = 2$.

The estimates in Column 5 of Table 2 indicate that 10% increase in foreign partner's GVA enhances Kyrgyzstan's trade flows by 4.67%. Since 1996, Kyrgyzstan's agricultural sector has reduced while trade flows, particularly, net imports have increased. Thus, our results confirm that Kyrgyzstan has substituted a domestic shortage of farm products with imports.

Distance as a proxy for the transportation cost is a significant impediment to bilateral trade. A ten percent increase in length restricts international trade between trading partners by 8.63% on average (Column 3). According to Head & Mayer (2014)[18], the estimated coefficient of distance is virtually close to the benchmark (–1). Interestingly, while the estimated coefficients of distance obtained from estimators with directional fixed effects (Column 2 and Column 3) are close to (–1), it significantly differs for pooled OLS (Column 1), confirming existing literature on inconsistent results without proper control on multilateral resistance terms.

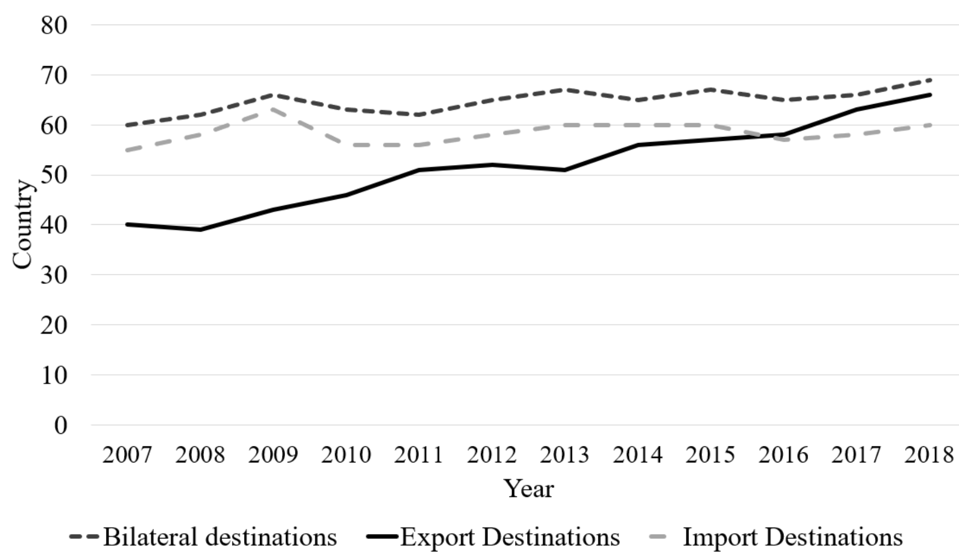
Firms vary in productivity and export choices in the Melitz (2003)[30] framework. Moreover, the rise in firms' productivity increases trade flows due to intensive and extensive margins. Our empirical results also show that the rise in farmers' average productivity increases trade flows

[11] The average estimate of σ is equal to 6.13 in the analysis of Head & Mayer (2014)[18].

between Kyrgyzstan and its trading partners (Columns 1, 2, 3), reflecting the Melitz (2003)[30] model's predictions by the extensive margin. However, its significance dropped with the exclusion of the time-invariant distance variable since the variability in productivity is small, and its effect is absorbed by other variables such as tariffs and GVA.

We compare Kyrgyzstan's trade destinations in 2007-2018 to predict the Melitz (2003)[30] framework's intensive margin effect (Figure 3). As shown in Figure 3, trade destinations in all directions (export and import) increased. In particular, the most significant change is observed in the export destination compared to import and bilateral destinations. Hence, our empirical results confirm all the theoretical framework predictions related to multilateral resistances, extensive and intensive margins.

Figure 3: **Evolution of Trade Agricultural Trade Destinations of Kyrgyzstan, 2000-2018**



Source: UN COMTRADE 2020, authors' calculations.

To summarize, our empirical analysis shows that the implementation of non-trade policies does not affect trade flows. In contrast, tariff rates as a bilateral trade policy is an essential factor in bilateral trade flows. Additionally, we can conclude that the benchmark regression results are robust to various sensitivity analyzes.

5 Conclusions and Policy Implications

Existing literature on structural gravity models is mainly based on the theoretical foundations of Anderson & van Wincoop (2003)[3] and Eaton & Kortum (2002)[13]. This study contributes to the existing literature by its novelty of theoretical upgrades such as modification and derivation of a Melitz-type structural gravity equation for small scale economies. Moreover, we show the importance of unilateral trade and non-trade policies in increasing international trade for emerging economies because the effect of implemented policies could vary with the country's size and development.

This paper examines the impact of trade and non-trade policies on international trade flows using our newly derived structural gravity model that incorporates all the gravity model's traditional variables, the variables specific to a Melitz (2003)[30] model, and the credit subsidy variable. In addition, we used cross-country panel data on agricultural products in Kyrgyzstan from 2007 to 2018. Empirical results lead to two main conclusions. First, agricultural credit subsidies are not efficient in increasing international trade flows.

The agricultural sector in Kyrgyzstan has continuously declined in the last two and a half decades due to the government's insufficient support and the country's infrastructure in the transition period. Moreover, farmers shifted from the unprofitable agricultural sector to profitable ones such as manufacture and service or migrated abroad. As a result, the country became heavily dependent on imports of farm goods due to the decline in GVA and the total employment in agriculture. To reduce reliance on importers and enhance domestic production of agricultural goods, the Kyrgyz government began to provide credit subsidies to farmers in 2013. Our research shows that this policy is ineffective in terms of international trade. Hence, policymakers need to be aware of the waste of resources and reconsider their decisions about this policy.

Second, bilateral applied tariffs act as a trade barrier and significantly reduce the number of exports from Kyrgyzstan. The annual sum of weighted applied tariffs imposed on the Kyrgyz agricultural products abroad increased from 474.13 in 2007 to 581.59 in 2018. Similarly, the yearly sum of weighted applied tariffs imposed on foreign agricultural products in Kyrgyzstan rose from

612 in 2007 to 654.71 in 2018, showing the interconnectedness of these two phenomena. Turkey, South Korea, and India put the highest tariff rates on Kyrgyz agricultural products while Kyrgyzstan mostly restricts agricultural products from Mexico, Georgia, and Ireland. Even though these countries (Turkey, South Korea, and India) put high tariff rates on our products, we mainly consume their products. Therefore, the Kyrgyz government should negotiate with these countries on a mutual reduction in applied tariff rates on agricultural products.

To summarize, the Kyrgyz government should invest more effort in bilateral trade deals, such as trade negotiations and agreements, than in its policy of subsidized loans. Moreover, our research shows that the cause of structural changes in international trade flows of agricultural commodities from 2014 was not implementing the subsidy policy. Further research with microdata is required to fully understand the nature of those structural changes, which is not the main focus of this study.

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