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Full length article

## 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 partners' applied tariff rates. We analyze bilateral agricultural trade flows between Kyrgyzstan and its 69 trading partners from 2007 to 2018 to test our theoretical findings. Applying the Poisson pseudo maximum likelihood estimator, we find that credit subsidies effectively increase international trade flows while applied tariffs imposed on agricultural products reduce Kyrgyzstan's export substantially. These results can be applied to similar economies with publicly available data where small budgetary efforts drive trade expansion.

### 1. Introduction

Previous analyzes of the impact of agricultural input subsidies covered a broad range of outcome indicators (e.g., Hemming et al., 2018). Many of them are of a microeconomic 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, Pham, and Ulubasoglu (2019) in the case of aggregated US farm subsidies. However, the effect of a single input policy instrument cannot be disentangled. Therefore, this study offers an alternative approach to disentangle 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. Agriculture differs from other export-oriented sectors in many aspects, particularly in countries dominated by a scattered farming sector such as Kyrgyzstan. First, products have to be pooled by some middlemen in order to reach viable quantities providing a disincentive to quality-enhancing investments at the producer level. Second, many transition economies are still characterized by a processing and wholesale sector fitting the large-scale agricultural structures of the past instead.

Existing international trade literature mainly evaluates trade policy instruments such as trade liberalization, regional trade agreements (RTAs), tariffs, quotas, and export subsidies, including credit subsidies (e.g., Carmichael, 1987; Chang, Chen, & Saito, 2021; Kuenzel & Sharma, 2021; Mah, 2006; Rees & Tyers, 2004). 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 (Defever, Imbruno, & Kneller,

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2013; Fu, Zhang, & Li, 2021). The impact evaluation analysis is almost impossible for large economies such as the European Union, which provides comprehensive agricultural input subsidies through many instruments. However, the analysis becomes feasible for small countries with few government support policies in the raw commodity sector, such as agriculture in Kyrgyzstan.

Agricultural support policies are still among the most debated issues in developing countries (Jayne, Mason, Burke, & Ariga, 2018). Evidence from North America, Europe, Asia shows that the governmental support for intensifying agriculture mechanization, technology, irrigation, and use of improved fertilizer led to increased farm productivity and agricultural growth (Fuglie, Gautam, Goyal, & William, 2020; Wang, Deng, & Deng, 2020). However, large fertilizer subsidy programs in Africa have resulted in several unintended negative impacts (Holden, 2019; Theriault & Smale, 2021). In this regard, the impact evaluation of Kyrgyzstan's farm supporting project, whose primary goal is to increase the export of agricultural goods, is essential.

We employ gravity model treating credit subsidies as non-trade and applied tariffs as trade policy to analyze multiple instruments at the macro level simultaneously. Gravity model, acquiring a range of micro-founded macro theoretical bases, is the most frequently used framework in applied international trade literature (e.g., Agnosteva, Anderson, & Yotov, 2014; Bergstrand, Larch, & Yotov, 2015; Dai, Yotov, & Zylkin, 2014; Fally, 2015; Jarreau, 2015; Wilson, Mann, & Otsuki, 2003). The policy studies focused on international trade use of Anderson and Van Wincoop (2003) model of perfect competition with homogeneous goods or an Eaton and Kortum (2002) model with sectoral heterogeneity. Both models assume that each firm's productivity is identical before entering the international market. However, Bernard, Jensen, Redding, and Schott (2007) 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) model of monopolistic competition with heterogeneous firms captures many empirical facts mentioned by Bernard et al. (2007) and the potential source for gains from trade (e.g., Arkolakis, Arnaud, & Rodríguez-Clare, 2012). Although the Melitz (2003) model provides the backbone for many trade papers written in the past decade, a few studies used this framework theoretically (e.g., Eaton, Kortum, & Kramarz, 2011; Helpman, Itzhoki, & Redding, 2010) and empirically (e.g., Bas & Bombarda, 2012; Chevassus-Lozza & Latouche, 2011; Eaton, Kortum, & Sotelo, 2012; Helpman, Melitz, & Rubinstein, 2008). To our best knowledge, no paper addresses the Melitz (2003) 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 & Chamberlain, 2019). 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 (Santos Silva & Tenreyro, 2006) using data from Kyrgyzstan.

Kyrgyzstan is a small, open, and developing economy with negative growth rates of foreign trade. Foreign trade turnover in 2013–2019 decreased by 12.7% – from USD 7.993 billion to USD 6.975 billion.<sup>1</sup> Exports in 2019 amounted to USD 1.986 billion and decreased by 1% compared to 2013, while imports amounted to USD 4.989 billion and decreased by 16.7%. The export potential of the agricultural sector in total export volume is approximate 10% (about USD 190 million per year on average over the past five years). At the same time, crop production plays a leading role (more than two-thirds of total agricultural output).<sup>2</sup>

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. This study aims to assess the effect of credit subsidies and applied tariff rates on trade flows of aggregated farm goods and suggest policy implications for the Kyrgyz government.

The contribution of our work to the existing literature is twofold. First, given the characteristics of the country and the relevance of a Melitz (2003) model, we extend a small and open economy model of Demidova and Rodríguez-Clare (2013) to identify the general equilibrium effects of bilateral trade and unilateral non-trade policies. Second, we illustrate a macro-level impact analysis of agricultural subsidies. Such an approach might be particularly useful in contexts with a rather heterogeneous agricultural sector and a lack of representative farm-level data.

The analyses are provided examining a Melitz-type structural gravity model using the PPML estimator due to its numerous advantages over other estimators in structural gravity models (Santos Silva & Tenreyro, 2006). 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. Empirical results show that credit subsidy policy does not significantly influence trade flows while applied tariffs substantially decrease the export of farm products, which is in line with theory.

The remainder of the paper is structured as follows. The next section provides the 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.

<sup>1</sup> Source: NSC KR, “Foreign Trade of the Kyrgyz Republic” for 2013–2020.

<sup>2</sup> Source: WTO, “Trade policy review WT/TPR/G/411”, 2021.



Fig. 1. Evolution of trade in agricultural goods, 2000–2018. 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.

Source: UN COMTRADE 2020, authors' calculations.

## 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 but it is no longer “a driver” of economic growth as it was in the second half of the 1990s (Light, 2007). 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). As of January 1, 2020, more than 453 thousand operating economic entities are operating in agriculture, forestry, and fishing. Among them, 341.1 thousand, or 75.5% of the total number of such entities, fell on peasant farms, 110.1 thousand entities, or 24.3% on individual entrepreneurs engaged in agricultural production.<sup>3</sup>

Kyrgyzstan is neighboring Kazakhstan, Uzbekistan, Tajikistan, and China. Although it is landlocked, it is geographically and economically well-positioned for international trade in 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). Despite substantial trade policy liberalization at the beginning of the transition phase, its export performance was 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. In addition, a significant deficit in agricultural machinery hinders sector productivity resulting in Kyrgyzstan's trade balance being negative since 2001 (Fig. 1).<sup>4</sup>

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 Fig. 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.<sup>5</sup> 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. A 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, scholars assess two as particularly successful in increasing farmers' productivity: private ownership and land redistribution. 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 & Sedik, 2009).

On the other hand, implemented reforms and the substantial decline in transfers from Moscow led to a massive budget deficit (about 17% of GDP). The Kyrgyz government tried to cushion the impact of withdrawing direct support from the USSR through indirect subsidies: tax exemptions from value-added tax, price support for irrigation services, price discount for electricity usage,

<sup>3</sup> Source: NSC KR “Agriculture of Kyrgyz Republic”, 2020.

<sup>4</sup> Source: FAO, “The Kyrgyz Republic Farm mechanization and agricultural productivity”, 2009.

<sup>5</sup> Source: Authors' calculations using UN COMTRADE data.

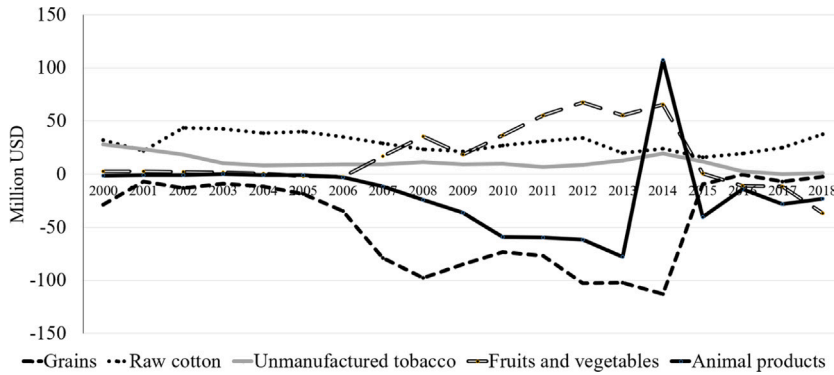


Fig. 2. Evolution of net trade in agricultural commodities, 2000–2018. Source: UN COMTRADE 2020, authors’ calculations.

and vaccinations usually provided by the finance obtained from international aid organizations. Moreover, only in 2013 did the government implement 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. The target sectors within the project are animal husbandry, crop production, and processing of agricultural products. Favorable interest rates fluctuate from 6% to 10% (market interest rates fluctuate from 22% to 30%), and crediting period up to 60 months, based on the target industry. The government has introduced additional preferred requirements related to farmers’ occupation and productivity because the total amount of support is restricted due to the limited state budget. One of the preferred requirements is being an exporter of agricultural products, which restricts small-scale farmers’ access to subsidized loans as they are oriented towards the domestic market.

### 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 and Rodriguez-Clare (2013) 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 a 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 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  $q_{ji}(\omega) = A p_{ji}(\omega)^{-\sigma}$  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  $\varphi$  which is sampled from a Pareto distribution with a cumulative distribution function<sup>6</sup> given by  $G_i(\varphi)$ . Knowing  $\varphi$ , the domestic market-oriented producer in country  $i$  faces variable costs  $\frac{w_i}{\varphi}$  while the export-oriented

<sup>6</sup> Our parametrization of the productivity function based on Chaney (2008). According to his assumption, productivity  $\varphi$  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  $g_i(\varphi) = \theta_i \varphi^{-\theta_i-1}$ .

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.<sup>7</sup> 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

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

### 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,  $E_\varphi \left[ \sum_j \max \{ \Pi_{ij}(\varphi), 0 \} \right] = w_i f_i^e$ .

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

$$M_i^e w_i f_i^e + M_i \int_{\varphi_{ij}^*}^{\infty} \left( q_{ij}(\varphi) \tau_{ij} \frac{(1 + r_i - s_i)(1 + \kappa_{ij})}{\varphi} + w_i f_{ij} \right) \frac{dG_i(\varphi)}{1 - dG_i(\varphi_{ij}^*)} = L_i (1 - \gamma_i) \tag{4}$$

where  $M_i^e$  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,<sup>8</sup> equilibrium consists of four ZCPs, two FEs, and two LMCs, making up a system of eight equations in eight unknown endogenous variables:  $\varphi_{ii}^*, \varphi_{jj}^*, \varphi_{ij}^*, \varphi_{ji}^*, M_i, M_j, w_i, w_j$ .

<sup>7</sup> 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.

<sup>8</sup> Detailed derivation of every condition can be presented upon request.



### 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  $\tilde{\varphi}_{ij} \equiv (\int_0^\infty \varphi^{\sigma-1} \mu_{ij}(\varphi) d\varphi)^{\frac{1}{\sigma-1}}$ .

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 and Van Wincoop (2003). 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).

We take the first-order derivatives of  $X_{ij}$  with respect to  $s_i$  and  $\kappa_{ij}$  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 Eqs. (5.1) and (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)).

Credit subsidies as a cost reducer influence demand through prices, which directly increase exporters' productivity and the product's trade flow. On the contrary, trade barriers such as applied tariff rates increase the cost of the product resulting in reduced trade. Besides trade policies affecting trade costs, domestic policies such as regional trade agreements (RTAs) and currency regimes are crucial in driving trade and external competitiveness by changing relative prices, which is not derived explicitly in our theoretical framework (Aman, Mallick, & Nemlioglu, 2021; Mallick & Marques, 2016; Yang & Mallick, 2014).

Melitz (2003) heterogeneous firm model is more sensitive to changes in trade costs than Krugman (1980) model of homogeneous firms due to the  $\theta_i > \sigma - 1$  assumption. Furthermore, it predicts a larger change in trade flows by considering intensive (exporting firms export more) and extensive (smaller firms start to export) margins, while Krugman (1980) model lacks the second effect. To capture all effects (multilateral resistances, intensive and extensive margins), we estimate Eq. (5) (Melitz-type gravity equation) applying 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) in all agri-food products 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, Piermartini, Monteiro, and Larch \(2016\)](#) guide for estimation purposes. They propose a comprehensive and theoretically-consistent gravity specification identifying bilateral and unilateral non-discriminatory trade policy effects. We include all other Melitz framework variables such as productivity and consumer price indices despite the lack of data on fixed costs and the number of exporters. We do not include the RTA dummy because applied tariff rates are calculated, including trade agreements; therefore, putting the RTA dummy into the regression would perfectly collinear with tariffs. With the reduction of import tariffs on agricultural and food products worldwide, the spread of non-tariff measures (NTMs) becomes vital for policymakers (e.g., [Cusolito & Hollweg, 2013](#)). Hence, our empirical analysis consists of the estimation of the following gravity equation with the inclusion of NTM:

$$X_{ij,t} = \exp \left[ \beta_1 \ln S_{i,t} + \beta_2 I_{ij,t} \times \ln S_{i,t} + \beta_3 \ln S_{i,t-2} + \beta_4 \ln T_{ij,t} + \beta_5 \ln N_{ij,t} + \beta_6 \ln V_{ij,t} + \beta_7 \ln Y_{j,t} + \beta_8 \ln D_{ij,t} + \beta_9 P_{j,t} + \pi_{i,t} + \chi_{j,t} + \lambda_{i,j} \right] \varepsilon_{ij,t} \quad (7)$$

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 that 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 and  $N_{ij,t}$  is NTMs on imported goods.  $V_{ij,t}$  represents the average productivity of farmers while  $Y_{j,t}$  indicates the production of agricultural goods of the destination country.  $D_{ij}$  shows the weighted distance between Kyrgyzstan and its trading partners (a 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](#)). In contrast, importers' increased tariff rates is associated with a small number 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,<sup>9</sup> consisting of exports and imports during 2007–2018 with 1656 observations. Agricultural trade encompasses the categories 01 to 24 of the eight-digit Harmonized System 2007 nomenclature. We used the United Nations COMTRADE database for data on international trade flows. The data on agricultural credit subsidies,<sup>10</sup> 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](#)) using trade and tariff rates from WTO's annual publications called “World Tariff Profiles”. We prefer import-weighted tariffs over simple averages because simple averages give the same weight to products that are not imported and those imported in large amounts, causing biasedness.<sup>11</sup> The data on NTMs was collected from UNCTAD's TRAINS database. The database covers import (technical and non-technical measures) and export measures as well as information on “procedural obstacles” (e.g., administrative burdens, transparency issues or infrastructural challenges). 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 and Zignago \(2011\)](#) for weighted international bilateral distances. We calculate the average productivity data<sup>12</sup> using GVA and employment in the agricultural sector. The total labor force in the agricultural sector is sourced from the World Bank's World Development Indicators (WDI).

[Table 1](#) provides descriptive statistics of all variables used in the empirical analysis.

#### 4.3. Methodology

We follow [Santos Silva and Tenreyro \(2006\)](#) to estimate our theoretical model with the PPML estimator<sup>13</sup> since our gravity model is in multiplicative form and it has several advantages over other estimators such as Tobit and OLS. First, it accounts for heteroscedasticity. Second, the PPML estimator can use information containing zeros in trade flows while other log-linear estimators

<sup>9</sup> 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.

<sup>10</sup> Credits are provided by the following interest rates: livestock — 10%, crop — 10%, processing — 8%.

<sup>11</sup> Source: WTO, “A Practical Guide to Trade Policy Analysis”, 2012.

<sup>12</sup> Average productivity of farmers is calculated as follows: Prod = GVA/labor force in the agricultural sector.

<sup>13</sup> Stata contains a built-in *ppml* command developed by [Santos Silva and Tenreyro \(2006\)](#) that can easily be applied to the gravity model.



**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
NTMs (number of measures)	8.17	54.60	0.00	699.00
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

exclude them or treating them with small values may bias the estimation results (Linders & Groot, 2006). Third, it is consistent in fixed effects as in simple OLS. Fourth, the PPML can also be used to calculate theory-consistent general equilibrium effects of trade policies (Larch & Yotov, 2016). 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 the multilateral resistances while pooled OLS does not.

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 consider 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, Mastromarco, Serlenga, & Shin, 2017). Such multi-dimensional models call for new econometric methods to deal with this issue which is 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.<sup>14</sup>

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 subsidy amount is too small 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.

Second, this policy could affect farmers' total productivity but not their export performance. Farmers could produce commodities that are mainly sold in the domestic market. A rise in the supply of agricultural products reduces farm products' import substitution due to the country's fixed demand for agricultural goods. 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.

Farmers could switch producing one type of agricultural commodity to another (see Fig. 2). To examine the impact of credit subsidies on the international trade of exporters and importers separately and whether the structural break in 2014 is related to any farm support policy or other external factors, we need disaggregated data on the production, labor, and production costs of exporters and importers, which could be the subject of future research. However, this break does not affect our results in the study because we take it into account and minimize it with exporter and importer time fixed effects.

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 (Aldashev, 2019). Over the years, their popularity has grown, increasing their expenses, thus forcing people to

<sup>14</sup> The total number of observations is 1656. Some of the observations are omitted due to perfect colinearity with time and pair fixed effects in the PPML estimations.

**Table 2**  
On the impact of subsidies and tariffs on international trade.

	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	PPML	PPML	PPML
Log credit subsidy	-0.016 (0.010)	-0.101 (0.061)	0.008 (0.027)	0.013 (0.027)	-0.006 (0.026)
Importer × log credit subsidy	0.042 (0.029)	0.083 (0.108)	0.104 (0.074)	0.066 (0.076)	0.077 (0.088)
Lagged log credit subsidy (t-2)					-0.028 (0.024)
Log weighted tariffs	-0.414*** (0.081)	-0.578*** (0.135)	-0.716*** (0.109)	-0.978*** (0.103)	-1.045*** (0.108)
NTM	0.004** (0.001)	0.633*** (0.159)	0.002** (0.001)	-0.001 (0.001)	-0.001 (0.001)
Log average productivity	0.420*** (0.078)	0.245** (0.077)	0.273*** (0.056)	0.016 (0.046)	0.020 (0.050)
Log gross value added	0.528*** (0.058)	0.478*** (0.051)	0.570*** (0.049)	0.457*** (0.046)	0.466*** (0.050)
Log distance	-1.821*** (0.142)	-0.814*** (0.201)	-0.880*** (0.114)		
Consumer price index	0.002 (0.002)	0.004 (0.003)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
Constant	13.310*** (1.468)	2.232 (2.333)	2.547 (1.386)	0.806 (1.261)	0.440 (1.312)
R-squared	0.242	0.224	0.210	0.303	0.327
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.

spend credit subsidies for other purposes. These effects could serve as an explanation that 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 Kyrgyzstan's increasing demand for imported goods.

Any investment needs time to result in a higher output. However, the two-year-long lagged subsidy variable's estimated coefficient 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<sup>15</sup> shows an 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, Jacquet, & Lozza, 2008; Heid, Larch, & Yotov, 2017). 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 ( $\sigma$ ) vary between 2 and 12 in the existing literature.<sup>16</sup> 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 PPML with pair-fixed effects can be slightly lower when  $\sigma$  takes a lower bound value,  $\sigma = 2$ .

As traditional trade barriers such as tariffs have been declining over time, there has been a concurrent upward trend in adopting various food safety standards such as NTMs. NTMs are driven by human health and environmental concerns which can be critical for farmers in achieving better product quality. However, the overall effect of NTMs on trade can be either positive or negative, depending on whether the trade-cost effect dominates or falls short of the demand-enhancing effect. Our results show that international trade in agricultural products has increased due to NTMs, as Kyrgyzstan has already complied with NTMs of major partners such as Russia and other Central Asian countries.

<sup>15</sup> We dropped from the regression for non-entanglement.

<sup>16</sup> The average estimate of  $\sigma$  is equal to 6.13 in the analysis of Head and Mayer (2014).

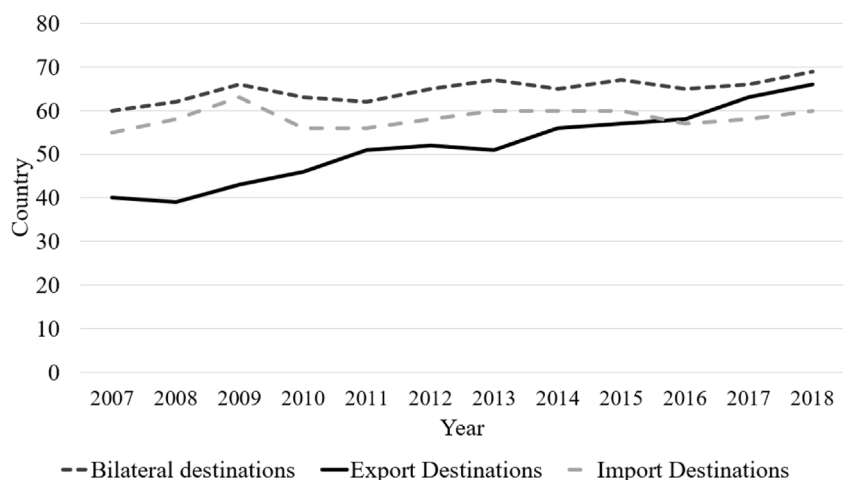


Fig. 3. Evolution of agricultural trade destinations of Kyrgyzstan, 2000–2018.  
Source: UN COMTRADE 2020, authors' calculations.

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

Distance as a proxy for 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 and Mayer (2014) 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) 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 between Kyrgyzstan and its trading partners (Columns 1, 2, 3), reflecting the Melitz (2003) model's predictions by the extensive margin. However, its significance dropped with excluding 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) framework's intensive margin effect (Fig. 3). As shown in Fig. 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.

To summarize, our empirical analysis shows that the implementation of non-trade policies does not affect trade flows. In contrast, tariff rates and NTMs as a bilateral trade policy are essential in bilateral trade flows. We can also conclude that the benchmark regression results are robust to various sensitivity analyses.

## 5. Conclusions and policy implications

Existing literature on structural gravity models is mainly based on the theoretical foundations of Anderson and Van Wincoop (2003) and Eaton and Kortum (2002). This study contributes to the existing literature by its novelty of theoretical upgrades such as modifying and deriving a Melitz-type structural gravity equation for small-scale economies. Moreover, we show the importance of bilateral trade and unilateral non-trade policies in stimulating 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 using a newly derived Melitz-type structural gravity model that incorporates all the gravity model's traditional and policy variables. According to our theoretical results, policy variables such as credit subsidies are trade-enhancing while trade barriers like applied tariffs are trade-reducing in small open economies. We test our theoretical results using 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. In Kyrgyzstan, the agricultural sector continuously declined in the last two and a half decades due to the government's insufficient support and the country's deteriorating infrastructure in the transition period. Moreover, farmers shifted from the unprofitable agricultural sector to profitable ones such as manufacturing 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 study shows that this policy is

not statistically effective in increasing international trade, which is consistent with studies analyzing other small countries such as Lithuania (Namiotko, Galnaityte, Balezentis, & Wang, 2019). Hence, our results suggest that a different use of financial resources could be more effective. Investments into public goods and services such as infrastructure, collection centers, grading facilities or farm extension and training might generate broader effects than the support of individual farms.

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 Kyrgyz products, imports from these countries to Kyrgyzstan are quite important. 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 for individual farmers. 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. Thus, our results may be relevant to other small countries that lack farm-level data or are characterized by a heterogeneous agricultural sector. Macroeconomic data are often easily accessible and can help in assessing policies' effects on trade.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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