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MICROLEVEL ANALYSES OF DSGE MODEL PARAMETERS: EVIDENCE FROM KAZAKHSTAN

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Abstract

Dynamic stochastic general equilibrium (DSGE) models are widely used by central banks, government agencies and financial organizations to conduct simulation and forecast relevant macroeconomic indicators in the economy. The most important inputs into all DSGE models are structural parameters which are either calibrated from other sources or estimated via Bayesian methods. Using non-public microlevel data, we estimate ten structural parameters for Kazakhstan: the elasticity of substitution between exports and imports, constant relative risk aversion, intertemporal elasticity of substitution in consumption, Frisch elasticity of labor supply, the depreciation rate of physical capital, capital and labor shares, and the elasticity of substitution between tradable and nontradable goods. Various econometric techniques such as fixed-effects, generalized method of moments (GMM), Arellano-Bond, and non-linear iterative maximum likelihood estimation are used to obtain consistent estimates of the models' coefficients. The structural parameters can be used in calibrated DSGE models as fixed parameters or as prior information in Bayesian estimation of the models.

Keyword: DSGE; CRRA; Frisch Elasticity of Labor Supply; Depreciation rate; Capital and Labor Shares; Nontradables.

JEL code: D10, D20, F10

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1. Introduction

Dynamic Stochastic General Equilibrium (DSGE) models have become one of the widespread tools for policy analysis at central banks, government agencies and financial organizations. These models allow us to conduct simulation experiments aimed at identifying the response of an economy to structural shocks and to produce forecasts under various scenarios. Hence, structural parameters of the model play a crucial role in the analysis of DSGE models and directly affect the results of these models. This paper focuses on estimating these parameters for Kazakhstan using micro-level data.

The number of research works on Kazakhstan are rather limited, and the current research extends the literature on the estimation of DSGE model parameters using unique microdata (see in Appendix A). The availability of rich household-, commodity-, and firm-level data from 2009 to 2018 is the main feature of the research. This is a good opportunity to obtain reliable results on structural parameters by exploring cross-sectional and panel datasets. Various econometric techniques are used to obtain consistent estimates of the parameters. These techniques capture simultaneity and selectivity biases by accounting the endogenous nature of variables and reporting robust standard errors.

There is a paucity of papers on DSGE models for Kazakhstan. One of the first works is proposed by Mukhamediev and Kakizhanova (2014). They estimate model parameters via Bayesian methods. Algozhina (2016) also uses macro-level data for the calibration of structural parameters of a medium scale open-economy model for Kazakhstan. Recently, Abilov (2020) estimates a small open-economy model for Kazakhstan via Bayesian techniques. However, all of the works resorting to Bayesian estimation of the model do not have reliable prior information for structural parameters. Therefore, the relevance of this work lies in obtaining consistent estimates of key structural parameters encountered in most of the DSGE models. Hence, we conduct a detailed study of structural parameters using non-public data from the Statistics Committee of the Republic of Kazakhstan.

The paper is structured as follows. Section 2 presents the estimation results on the elasticity of substitution between export and import goods. Section 3 discusses constant relative risk aversion and intertemporal elasticity of substitution in consumption. Section 4 and 5 describe the Frisch elasticity of labor supply and depreciation rate of physical capital. Section 6 presents the analysis of capital and labor shares. Section 7 provides the results on the elasticity of substitution between tradable and nontradable goods. Section 8 summarizes the main findings of the paper.

2. Elasticity of substitution between export and import goods

The elasticity of substitution between export and import goods is a measure of trade sensitivity to the change in relative prices of export and import goods. This section presents the estimation of elasticity of substitution in demand between exports and imports using commodity level data for about 96 categories of industries in Kazakhstan.

In traditional trade theory, exportable goods (or domestically produced) and imported goods are assumed to be perfect substitutes. However, imports and domestic goods are not identical and consumers tend to demand both imports and exportable goods. Therefore, Armington's framework is employed to take into account the lower degree of substitutability between imports and exports (Armington (1969)). The larger the value of Armington elasticity, the higher is the degree of substitution between domestically produced goods and imports.

2.1. Methodology

The elasticity of substitution between export and import goods for industry i, denoted by ϕ_i, is defined as the ratio between the percentage change in relative quantities and the percentage change in relative prices. The formula of the elasticity of substitution and the regression model specification are given below.

$$\phi_i = \frac{\Delta\left(\frac{Q_i^m}{Q_i^x}\right) / \frac{Q_i^m}{Q_i^x}}{\Delta\left(\frac{P_i^x}{P_i^m}\right) / \frac{P_i^x}{P_i^m}} \tag{1}$$

$$\log\left(\frac{Q_{it}^m}{Q_{it}^x}\right) = \delta + \phi \log\left(\frac{P_{it}^x}{P_{it}^m}\right) + \epsilon_{it} \tag{2}$$

where Q_{it}^m and Q_{it}^x are quantity indices of imports and exports respectively; P_{it}^m and P_{it}^x are price indices of imports and exports; ϕ is the elasticity of substitution; ϵ_{it} is an error term.

According to Sauquet et al. (2011), I include the lag of the dependent variable in the model to take into account a long-term relationship between quantities and prices, and it also increase the explanatory power of the regression model.

$$\log\left(\frac{Q_{it}^m}{Q_{it}^x}\right) = \delta + \alpha \log\left(\frac{Q_{it-1}^m}{Q_{it-1}^x}\right) + \phi \log\left(\frac{P_{it}^x}{P_{it}^m}\right) + v_{it} + \mu_t + \epsilon_{it} \tag{3}$$

where v_i is an individual specific effect; μ_t is a time fixed effect. We employ a fixed-effects (FE) panel data specification to capture unobserved time-invariant heterogeneity of industries. The model also controls for potential macroeconomic fluctuations in the economy by introducing time fixed-effects. However, there is a danger of inconsistency, if the panels are short. Therefore, Arellano-Bond's and Arellano-Bover's generalized method of moments (GMM) methods are adopted. According to Arellano and Bond (1991), lagged values of the first difference can be used as instrumental variables (IV) to capture the endogeneity problem and to address individual effects. Lately, Arellano and Bover (1995) proposed an expanded version of this technique by using lags in differences together with lags in levels as instruments. Finally, Labra and Torrecillas. (2018) point out that two-step GMM is more efficient than one-step estimator.

2.2. Data

Annual data on trade comes from the State Revenue Committee of the Ministry of Finance and the Statistics Committee of the Ministry of National Economy for the period from 2009 to 2018. However, there is no data on average prices, therefore, we calculate them using micro data at a 10-digit HS[1] level in order to obtain accurate proxies for average prices. Then we aggregate the data by 96 industries using the Laspeyres price and volume indices to convert them into the same units of measurement. The methodology of aggregation is in line with the approach of the Statistics Committee:

$$I_p = \frac{\sum \frac{P_t^i}{P_{t-1}^i}\left(P_{t-1}^i * Q_0^i\right)}{\sum P_0^i Q_0^i} * 100 \tag{4}$$

$$I_q = \frac{\sum Q_t^i * P_0^i}{\sum P_0^i Q_0^i} * 100 \tag{5}$$

where I_p is a price index; I_q is a volume index; subscripts i and t correspond to goods and prices respectively. We take 2013 as the base year.

2.3. Results

The regression results are presented in Table 1 below. The table shows us that the elasticity of substitution between exports and imports is less than one. The lower is the elasticity of substitution, the greater is the heterogeneity between goods. According to the Arellano and Bond (1991) approach, a 1% increase in the price of exports relative to imports leads to the increase of imports relative to exports by 0.54%. A possible explanation is a high heterogeneity between export and import goods, because Kazakhstan mainly exports primary products, which constitutes more than 70 percent of total exports. At the same time Kazakhstan mainly imports finished products. Therefore, the degree of substitutability between export and import products is expected to be low.

[1] Harmonized System of international product nomenclature

	OLS	FE	FE IV	Arellano-Bond	Arellano-Bover
$\log\left(\frac{P^x_{it}}{P^m_{it}}\right)$	0.130**	0.266***	-0.117	**0.544*** **	0.123
	(2.27)	(3.28)	(-0.17)	(2.68)	(0.85)
$\log\left(\frac{M_{it-1}}{X_{it-1}}\right)$	0.462***	0.229***	0.271***	0.136*	0.245***
	(9.62)	(4.00)	(3.44)	(1.93)	(3.63)
year	-0.052***	-0.057***	-	-0.025	-0.035*
	(-3.68)	(-3.33)		(-1.16)	(-1.89)
Constant	104.638***	114.039***	-	51.134	69.372*
	(3.67)	(3.33)		(1.16)	(1.89)
N	807	807	805	710	807
R^2	0.257	0.133	0.028		

t statistics in parentheses, $*p < 0.10, **p < 0.05, ***p < 0.01$

Table 1: Elasticity of substitution between export and import goods

3. Constant relative risk aversion

A relative risk aversion coefficient (denoted as σ) is a measure of household's degree of risk aversion. The inverse of constant relative risk aversion ($1/\sigma$) is also known as the coefficient of intertemporal substitution of consumption, which reflects the sensitivity of household's consumption growth to changes in real interest rates.

3.1. Methodology

We make a common assumption about the form of the utility function $u_i(c)$. It is assumed to be a constant relative risk aversion utility function that is comparable across households:

$$u_i(c) = \begin{cases} \frac{c^{1-\sigma}-1}{1-\sigma} & \text{if } \sigma \neq 1, \\ \log(c) & \text{if } \sigma = 1 \end{cases} \tag{6}$$

where σ is the relative risk aversion coefficient, and c is consumption. Along with Layard et al. (2008) and Gandelman and Hernández-Murillo (2013), we also hypothesize on the relation between utility and happiness, allowing a strictly monotonic non-linear relationship (defined by function f) common to all individuals:

$$h_{it} = f(\gamma u(c_{it}) + X_{it}\beta + \epsilon_{it}) \tag{7}$$

$$h_{it} = f\left(\gamma \frac{c_{it}^{1-\sigma} - 1}{1-\sigma} + \beta_1 female + \beta_2 age + \beta_3 age^2 + \epsilon_{it}\right) \tag{8}$$

where h_{it} is the happiness index that is calculated based on the survey data of households, which contains questions on the overall level of satisfaction with economic well-being. We include dummies into the model to control for gender and age factors of respondents.

An iterative maximum likelihood estimation (MLE) of the nonlinear model is employed to estimate the constant relative risk aversion. Initially, we compute a log-likelihood for values of σ between 0 and 10 in step size of 0.1, and then in steps of 0.01 in the vicinity of maximum obtained from the previous step. Then we apply the ordered logit method for each of the previous computations to calculate the coefficients of the model. Top and bottom five percentiles of consumption are eliminated as extreme values (see Layard et al. (2008)) to remove the effect of outliers.

3.2. Data

Quarterly cross-sectional data on household consumption (D-003, D-004) and annual data on their well-being (D-002) are compiled by the Statistics Committee. The data covers approximately 12,000 households in 2018. We convert quarterly consumption data into annual data in order to estimate the model specified above . Households' satisfaction with their economic well-being and financial capacity are taken as a proxy for happiness. The level of satisfaction is ranked from 1 to 10, with 1 being extremely dissatisfied and 10 being extremely satisfied.

	2018
Constant relative risk aversion (σ)	**2.71*** **
	(66.01)
Elasticity of intertemporal substitution in consumption ($\frac{1}{\sigma}$)	**0.369**

$^{***}p < 0.01$, χ^2 in parentheses.

Table 2: CRRA results

3.3. Results

Table 2 presents the estimated coefficient of the constant relative risk aversion. It takes the value of 2.71 in Kazakhstan, which implies that households in Kazakhstan are more risk-averse and prefer to invest in safer assets. Szpiro and Outreville (1988) show that this coefficient varies from 1 to 5 with an average of 2.89 in their study of 31 countries. However, Gandelman and Hernández-Murillo (2013) find smaller values of CRRA coefficients ranging from 0 to 3 with an average of 0.98.

The inverse of the constant relative risk aversion($\frac{1}{\sigma}$) is the intertemporal elasticity of substitution in consumption that shows the behavior of households' consumption relative to changes in real interest rates. Havranek et al. (2015) find that the average elasticity is 0.5 with a standard deviation of 1.5 among 169 published works for different countries. This elasticity is relatively low in Kazakhstan with the value of 0.37, implying that households tend to consume more in the current period rather than in the future. Various studies show that the intertemporal elasticity of substitution in consumption is lower in countries with low income and poor households, since they are less likely to replace consumption during their lifetime due to the difficulty of meeting their needs today. The CRRA parameter plays a crucial role in all DSGE models as well as in many other multiperiod models studying fiscal or pension policy.

4. Frisch elasticity of labor supply

Frisch elasticity of labor supply is one of the key parameters in most of the real business cycle models. It represents the response of hours worked to aggregate wage fluctuations in the economy.

4.1. Methodology

Frisch elasticity of labor supply (denoted as η_t) is a measure of sensitivity of labor supply to changes in wages given the marginal utility of wealth:

$$\eta_t = \frac{dh_t/h_t}{dw_t/w_t}|\lambda_t \tag{9}$$

$$\Delta \log h_t = \eta \Delta \log w_t + \eta \Delta \log \lambda_t \tag{10}$$

where h_t is hours worked, w_t is the wage rate, λ_t is marginal utility of wealth. The marginal utility of wealth is part of unobservable variables. Therefore, we employ instrumental variables (IV) estimation to avoid the problem of endogeneity. A lagged value of wage difference is a common instrument in most studies (e.g. Domeij and Floden (2004); Altonji (1986)). Following MaCurdy (1981) and Altonji (1986), we estimate the Frisch labor-supply elasticity by regressing the percentage changes in hours worked on percentage changes in wage rate. The model specification in logarithms is as follows:

$$\Delta \log h_{it} = \alpha + \eta \Delta \log w_{it} + \Delta \xi_{it} \tag{11}$$

4.2. Data

Annual data on firms (1-T) named "Report on Labor" is obtained from the Statistics Committee. The data set consists of 72,270 observations for all legal entities and their separate divisions with more than 100 workers spanning the period from 2009 to 2017, except for small enterprises reporting the 2-MP statistical form.

	D.log(hours)	D.log(workers)
D.log(wage)	**1.979*** **	**2.114*** **
	(6.565)	(6.590)
Constant	-0.035***	-0.036***
	(-5.875)	(-5.641)
N	49226	49226
N of groups	10,434	10,434
R^2	0.688	0.726

z statistics in parentheses, lag of d.log(wage) is used as IV
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Frisch elasticity of labor supply

4.3. Results

Table 3 demonstrates the regression results of Equation 11. Frisch elasticity of labor supply takes the value of 1.979 when hours worked are used as a dependent variable. It implies that a one percentage point increase in the growth rate of firms' wage fund leads to an increase of the growth rate of the number of man-hours by 1.979 percentage points. According to the second column of Table 3, an increase in the growth rate of wage fund by one percentage point increases the growth rate of the number of employees by 2.114 percentage points.

5. Depreciation rate of physical capital

The depreciation rate of physical capital (denoted as δ) is the rate at which the value and efficiency of capital stock diminishes.

5.1. Methodology

We use the standard capital-investment evolution equation known as the perpetual inventory method (PIM) to estimate the depreciation rate of capital stock. The stock of capital increases with investment and decreases at the depreciation rate.

$$K_t = (1 - \delta)K_{t-1} + I_t \tag{12}$$

where δ is the rate of depreciation of capital, K_t is capital stock and I_t is investment in physical capital in period t. Following Schundeln (2013), we rearrange Equation 12 and express in logarithmic form:

$$K_t - I_t = (1 - \delta)K_{t-1} \tag{13}$$

$$\log(K_t - I_t) - \log(K_{t-1}) = \log(1 - \delta) \tag{14}$$

$$\log(K_t - I_t) - \log(K_{t-1}) = \log(1 - \delta) + \epsilon_t \tag{15}$$

where ϵ_t is a disturbance term. Together with the simple pooled OLS approach, Equation 15 is estimated via fixed-effects (FE) and random-effects (RE) panel data models. In addition, we include time and sector dummies in the regression model in order to account for the effect of inflation due to the possible measurement errors in deflators.

$$\log(K_t - I_t) - \log(K_{t-1}) = \log(1 - \delta) + year_t + industry_t + \epsilon_t \tag{16}$$

where *year* and *industry* are the time and sector dummies. After obtaining estimates for the constant, denoted by c, the rate of capital depreciation is calculated as follows:

$$\log(1 - \delta) = c \tag{17}$$

$$\delta = 1 - \exp(c) \tag{18}$$

5.2. Data

Annual data on fixed assets of firms, called called the form "11", is also obtained from the Statistics Committee of Kazakhstan for the period from 2015 to 2018. The data set includes about 10,000 medium and large enterprises with more than 100 employees, with a total of 32,234 observations.

5.3. Results

The estimated results of the model are presented in Table 4 and indicate that the depreciation rate is equal to 8.3%, 1-exp(-0.086)=0.083, according to

	OLS	Panel RE	Panel FE	Panel RE with industry
Constant	-0.082***	**-0.086*** **	-0.070***	**-0.115*** **
	(-21.88)	(-22.31)	(-23.39)	(-6.33)
Services	-	-	-	**0.041** **
				(2.196)
Mining	-	-	-	-0.009
				(-0.330)
Manufacture	-	-	-	0.030
				(1.458)
Utilities	-	-	-	0.017
				(0.501)
Construction	-	-	-	**-0.050** **
				(-2.002)
Time dymmies	Yes	Yes	Yes	Yes
N	32,234	32,234	32,234	32,234
R^2	0.761		0.861	

z statistics in parentheses, $*p < 0.10, **p < 0.05, ***p < 0.01$
Reference industry is "Agriculture"

Table 4: Depreciation rate of physical capital

the random-effects method. After adding industry dummies, the depreciation rate takes the values of 7.2%, 10.9% and 15.3% for services, ggriculture, and construction sectors respectively. It is worth noting that the depreciation rate of physical capital in the construction and agriculture sectors are much higher than in services sector due to the structural differences of these industries.

6. Capital and labor share

A Cobb-Douglas form of production function with constant returns to scale is a common assumption made in economic theory. One of the main goals of researchers is to obtain consistent estimates of capital and labor shares of the Cobb-Douglas production function. Several methodologies have been designed to specifically address the problem of simultaneity and selection bias when estimating the capital and labor shares via regression analysis. The simultaneity arises due to the correlation between inputs (capital and labor) with unobservable productivity shocks. Firms choose inputs knowing the level of productivity, and this introduces a bias in OLS parameter estimates. There are numerous approaches to addressing this issue: IV estimation, fixed-effects approach, control functions, and GMM. Input prices are candicates for the role of instruments in IV estimation. However, finding an appropriate instrument for capital is the main problem of this method. Regarding the fixed-effects model, which controls for unobservable heterogeneity across firms, it requires the productivity shock to be fixed over time, and a strict endogeneity of inputs conditional on firms' heterogeneity (Wooldridge (2005)) which does not hold in theory. Therefore, in order to address all of these issues we resort to control functions and GMM estimation.

6.1. Methodology

Control functions method is a semiparametric method introduced by Olley and Pakes (1996) where investments are introduced through semiparametric function to control for unobservable productivity shocks. They develop a two-step estimation procedure to resolve the pathologies of simultaneity and selection bias present in OLS. We specify the Cobb-Douglas production function in logarithmic form for estimating the model parameters:

$$y_t = \alpha_0 + \alpha_l l_t + \alpha_k k_t + w_t + \eta_t \tag{19}$$

where y_t is output; k_t is capital (measured by fixed assets); l_t is labor (measured by man-hours); w_t is a productivity shock; ϵ_t is an error term. In perfect competition, the number of investments depend on capital and productivity.

$$i_{it} = i_t(k_{it}, w_{it}) \tag{20}$$

We assume that investments are invertible and monotonically increasing in productivity along with Olley and Pakes (1996):

$$w_{it} = h_t(k_{it}, i_{it}) \tag{21}$$

$$y_{it} = \alpha_0 + \alpha_l l_{it} + \alpha_k k_{it} + h_t(k_{it}, i_{it}) + \eta_t \tag{22}$$

$$= \alpha_l l_{it} + \phi_t(k_{it}, i_{it}) + \eta_t \tag{23}$$

$$\text{where} \quad \phi_t(k_{it}, i_{it}) = \alpha_0 + \alpha_k k_{it} + h_t(k_{it}, i_{it}) \tag{24}$$

The above partially linear model of y_{it} given by Equation 23 can be estimated by OLS, where $\phi(*)$ is approximated by a third-order polynomial. It resolves the problem of unobserved productivity, and thus, gives a consistent estimate of labor. Then, we estimate the following equation via non-linear least squares (NLS) to obtain the coefficient of capital:

$$y_{it} - \hat{\alpha_l} l_{it} = \alpha_k k_{it} + g(\hat{\phi}_{t-1} - \alpha_k k_{i,t-1}) + \epsilon_{it} + \eta_{it} \tag{25}$$

where the function $g(\cdot)$ is estimated by a higher order polynomial approximation.

Wooldridge (2009) proposed a new estimation technique using GMM framework to modify control functions method. His approach has several advantages over the two-step approach. First, it addresses an identification problem highlighted by Ackerberg et al. (2006) who find that the assumptions of previous approach hold if there is some variation in the data. If not, labor and the non-parametric term suffer from collinearity, because firms choose the variable input at some point in time depending on its capital and productivity. Second, it accounts for heteroskedasticity and serial correlation by obtaining robust standard errors. The model equations and description are given below.

$$y_{it} = \alpha_0 + l_{it}\alpha_l + k_{it}\alpha_k + c_{it}\lambda + e_{it} \tag{26}$$

$$y_{it} = \eta_0 + l_{it}\alpha_l + k_{it}\alpha_k + \sigma_1(c_{i,t-1}\lambda) + ... + \sigma_G(c_{i,t-1}\lambda)^G + \epsilon_{it} \tag{27}$$

where y_{it} is output, l_{it} - labor, k_{it} - capital, m_{it} - intermediate inputs, e_{it} and ϵ_{it} are error terms, and $c_{it}\lambda = c(k_{it}, m_{it})\lambda$ is a function of $h(k_{it}, m_{it})$ containing polynomials of order three or less:

$$h(k_{it}, m_{it}) = \lambda_0 + c(k_{it}, m_{it})\lambda \tag{28}$$

We have the following instruments for Equation 26 and 27:

$$z_{it1} \equiv (1, l_{it}, k_{it}, c^0_{it}) \tag{29}$$

$$z_{it2} = (1, l_{i,t-1}, k_{i,t-1}, c_{i,t-1}, q_{i,t-1}) \tag{30}$$

where c^0_{it} is similar to c_{it} but independent of k_{it}; $q_{i,t-1}$ is a set of nonlinear functions of $c_{i,t-1}$.

6.2. Data

The data (1-PF and 1-T) are obtained from the Statistics Committee for all medium and large size firms except for educational and medical organizations, banks, public associations, and insurance companies. These data sets are collected annually from firms with more than 50 employees from 2009 to 2014, and from firms with more than 100 employees since 2015 after changing the data collection methodology. We limit the entire sample to firms with more than 100 employees from 2009 to 2017 to analyze the panel data. The data consists of about 5,700 firms for the period between 2009 and 2017.

6.3. Results

Panel A of Table 5 presents the estimated shares of factors of production. The capital and labor shares are 0.35 and 0.65 respectively. These results are in line with the widespread values for these parameters in the literature. We also use the number of workers instead of hours-worked for the robustness check of the baseline results. It can be seen that the shares obtained by the control function method are the same as the previous values, while the GMM approach results in capital and labor shares of 0.40 and 0.60 respectively. In addition,

Panel A: capital and labor share of the country				
	number of workers		man hours	
parameters	Control functions	GMM	Control functions	GMM
capital share	0.35***	0.40***	0.35***	**0.35*** **
labor share	0.65***	0.60***	0.65***	**0.65*** **
N	6,197 (1,735)	22,252 (5,702)	6,197 (1,735)	22,250 (5,701)
Panel B: capital and labor share of nontradables*				
capital share		0.25***		**0.26*** **
labor share		0.75***		**0.74*** **
N		8,796 (2,655)		8,796 (2,655)

*I use services as a proxy for nontradables,
$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 5: Capital and labor share estimation results

we estimate capital and labor shares using services as a proxy for nontradables, and find that the nontradable sector is predominantly labor-intensive with the labor share of 0.74 (see Panel B of Table 5).

7. Elasticity of substitution between tradable and nontradable goods

This section is aimed at the estimation of elasticity of substitution in demand between tradable and nontradable goods using cross-sectional data for about 177 countries including Kazakhstan.

7.1. Underlying Model (Akinci (2011))

We assume that the utility function takes the following functional form:

$$u(t,n) = \frac{[t^{-\mu_{tn}} + n^{-\mu_{tn}}]^{1-\sigma}}{1-\sigma} \tag{31}$$

where t denotes tradable goods, n is nontradable goods, $\frac{1}{1+\mu_{tn}}$ is a constant elasticity of substitution between tradables and nontradables.

7.2. Methodology

Following Akinci (2011), we regress the logarithm of relative expenditures on the logarithm of relative prices, and the logarithm of GDP per capita to take into account the income effect.

$$\log\left(\frac{C_i^n}{C_i^t}\right) = \alpha_0 - \frac{1}{1+\mu_{tn}} \log\left(\frac{P_i^n}{P_i^t}\right) + \beta \log(GDPc_i) \tag{32}$$

where C_i^t and C_i^n denote expenditure shares on tradable and nontradable goods for each country i respectively; P_i^t and P_i^n are price indices for tradable and nontradable goods; $GDPc_i$ is GDP per capita.

7.3. Data

The cross-sectional data, known as "International Comparison Program (ICP) 2011", is obtained from the World Bank official website. The data set includes variables such as expenditure shares of GDP, real GDP per capita, and price indices for different categories of goods and services for 177 countries. Nontradables are defined as the sum of services and construction, and the rest are tradable goods. Price indices of tradable and nontradable goods are calculated by normalizing by the US price index=100.

7.4. Results

The regression results demonstrate that the elasticity of substitution between tradable and nontradable goods takes the value of 0.761 in 2011 for developing and developed countries (see Table 6). A similar result of 0.74 is obtained by Mendoza (1992) for 1975. According to Ostry and Carmen (1992), this value varies from 0.75 to 1.50 for developing countries.

	$\log\left(\frac{C_i^n}{C_i^t}\right)$
$\log\left(\frac{P_i^n}{P_i^t}\right)$	**0.761****
	(2.115)
$\log(GDPc_i)$	0.188***
	(2.789)
Region dummy	Yes
Constant	- 2.017**
	(-2.350)
N	177
R^2	0.399

z statistics in parentheses

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 6: Elasticity of substitution between tradables and nontradables

8. Conclusion

In conclusion, this paper provides estimates of commonly used structural parameters of DSGE models using micro data for Kazakhstan. The structural parameters have been estimated using various econometric techniqies to obtain robust estimates and standard errors of parameters. The values of structural parameters are in line with the literature for developing and developed countries. The main findings of the research are summarized in Table 7 below.

#	Parameter	Value
1	elasticity of substitution between export and import goods (ϕ)	0.54
2	constant relative risk aversion (σ)	2.71
3	intertemporal elasticity of substitution ($1/\sigma$)	0.37
4	Frisch elasticity of labor supply (η)	1.98 (2.11)
5	depreciation rate of physical capital (δ)	7.2 - 15.3
6	capital share ($1-\alpha$)	0.35
7	labor share (α)	0.65
8	capital share of nontradables ($1-\alpha_{nt}$)	0.26
9	labor share of nontradables (α_{nt})	0.74
10	elasticity of substitution between tradable and nontradable goods (μ_{tn})	0.761

Table 7: Structural parameters of DSGE models for Kazakhstan

The elasticity of substitution between exportable and importable goods takes the value of 0.54, which is similar to the one obtained by Miyamoto and Nguyen (2014) for Canada. The low value of the elasticity of substitution is confirmed by the heterogeneity of the country's export and import structure. Kazakhstan, as a developing country, is mainly an exporter of raw materials, while it imports finished products from abroad. Therefore, imported goods are rather complements to domestically produced goods.

Risk aversion is a behavior of households of avoiding risky investments. The value of the constant relative risk aversion is 2.71, which implies that households in Kazakhstan are less risky and prefer to invest in safe assets. Households in Uzbekistan are similarly more risk-averse (2.96), while in Kyrgyzstan (1.81) and Tajikistan (1.19) they are less so (see Gandelman and Hernández-Murillo (2014)). The inverse of the constant relative risk aversion is the intertemporal elasticity substitution in consumption which is equal to 0.37. This means that households consume more in the current period than in the next period. Hence, households tend to save less in Kazakhstan This parameter shows household's consumption sensitivity to changes in the interest rate in the country, and plays an important role in many models for fiscal policy analysis and consumer behavior.

The next parameter is the Frisch labor supply elasticity, which implies that, on average, a one percentage point increase in wage growth rate leads to 1.979 percentage points increase in working hours in Kazakhstan. This value corresponds to the generally accepted labor supply elasticity in common business cycle models.

In addition, the results for depreciation rate imply that physical capital in Kazakhstan depreciates at the rate of 8.3 percent per annum, while most researchers use a common value of 10 percent for developed countries. A depreciation rate shows the rate of amortization due to the utilization intensity of fixed capital. In a sectoral breakdown, the depreciation attains 15.3 percent in construction, while the figure is 7.2 percent in services.

The aggregated shares of capital and labor for Kazakhstan are 0.35 and 0.65

respectively. It correspond to the shares in developed countries. In addition, we find that the sector of nontradable goods is predominantly labor-intensive with a labor share of 0.74, which implies that the production of nontradable goods exploits much more labor than than the average in the economy. Finally, the estimated elasticity of substitution between tradable and nontradable goods is about 0.76 for 177 world countries, including Kazakhstan, meaning that the degree of substitutability is low across tradable and nontradeable goods.

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Appendix A.

HS Code	Name
01	Live animals
02	Meat and edible meat offal
03	Fish and crustaceans, molluscs and other aquatic invertebrates
04	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included
05	Products of animal origin, not elsewhere specified or included
06	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage
07	Edible vegetables and certain roots and tubers
08	Edible fruit and nuts; peel of citrus fruit or melons
09	Coffee, tea, maté and spices
10	Cereals
11	Products of the milling industry; malt; starches; inulin; wheat gluten
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder
13	Lac; gums, resins and other vegetable saps and extracts
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included
15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes
16	Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates
17	Sugars and sugar confectionery
18	Cocoa and cocoa preparations
19	Preparations of cereals, flour, starch or milk; pastrycooks' products
20	Preparations of vegetables, fruit, nuts or other parts of plants
21	Miscellaneous edible preparations
22	Beverages, spirits and vinegar
23	Residues and waste from the food industries; prepared animal fodder
24	Tobacco and manufactured tobacco substitutes
25	Salt; sulphur; earths and stone; plastering materials, lime and cement
26	Ores, slag and ash
27	Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes
28	Inorganic chemicals; organic or inorganic compounds of precious metals, of rareearth metals, of radioactive elements or of isotopes
29	Organic chemicals
30	Pharmaceutical products
31	Fertilisers
32	Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other colouring matter; paints and varnishes; putty and other mastics; inks
33	Essential oils and resinoids; perfumery, cosmetic or toilet preparations
34	Soap, organic surface-active agents, washing preparations, lubricating preparations, artificial waxes, prepared waxes, polishing or scouring preparations, candles and similar articles, modelling pastes, 'dental waxes' and dental preparation
35	Albuminoidal substances; modified starches; glues; enzymes
36	Explosives; pyrotechnic products; matches; pyrophoric alloys; certain combustible preparations
37	Photographic or cinematographic goods
38	Miscellaneous chemical products
39	Plastics and articles thereof
40	Rubber and articles thereof
41	Raw hides and skins (other than furskins) and leather
42	Articles of leather; saddlery and harness; travel goods, handbags and similar containers; articles of animal gut
43	Furskins and artificial fur; manufactures thereof
44	Wood and articles of wood; wood charcoal

45	Cork and articles of cork
46	Manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork
47	Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard
48	Paper and paperboard; articles of paper pulp, of paper or of paperboard
49	Printed books, newspapers, pictures and other products of the printing industry; manuscripts, typescripts and plans
50	Silk
51	Wool, fine or coarse animal hair; horsehair yarn and woven fabric
52	Cotton
53	Other vegetable textile fibres; paper yarn and woven fabrics of paper yarn
54	Manmade filaments; strip and the like of manmade textile materials
55	Manmade staple fibres
56	Wadding, felt and nonwovens; special yarns; twine, cordage, ropes and cables and articles thereof
57	Carpets and other textile floor coverings
58	Special woven fabrics; tufted textile fabrics; lace; tapestries; trimmings; embroidery
59	Impregnated, coated, covered or laminated textile fabrics; textile articles of a kind suitable for industrial use
60	Knitted or crocheted fabrics
61	Articles of apparel and clothing accessories, knitted or crocheted
62	Articles of apparel and clothing accessories, not knitted or crocheted
63	Other madeup textile articles; sets; worn clothing and worn textile articles; rags
64	Footwear, gaiters and the like; parts of such articles
65	Headgear and parts thereof
66	Umbrellas, sun umbrellas, walking sticks, seatsticks, whips, ridingcrops and parts thereof
67	Prepared feathers and down and articles made of feathers or of down; artificial flowers; articles of human hair
68	Articles of stone, plaster, cement, asbestos, mica or similar materials
69	Ceramic products
70	Glass and glassware
71	Natural or cultured pearls, precious or semiprecious stones, precious metals, metals clad with precious metal, and articles thereof; imitation jewellery; coin
72	Iron and steel
73	Articles of iron or steel
74	Copper and articles thereof
75	Nickel and articles thereof
76	Aluminium and articles thereof
78	Lead and articles thereof
79	Zinc and articles thereof
80	Tin and articles thereof
81	Other base metals; cermets; articles thereof
82	Tools, implements, cutlery, spoons and forks, of base metal; parts thereof of base metal
83	Miscellaneous articles of base metal
84	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof
85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles
86	Railway or tramway locomotives, rolling stock and parts thereof; railway or tramway track fixtures and fittings and parts thereof; mechanical (including electromechanical) traffic signalling equipment of all kinds
87	Vehicles other than railway or tramway rolling stock, and parts and accessories thereof
88	Aircraft, spacecraft, and parts thereof

89	Ships, boats and floating structures
90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; parts and accessories thereof
91	Clocks and watches and parts thereof
92	Musical instruments; parts and accessories of such articles
93	Arms and ammunition; parts and accessories thereof
94	Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, not elsewhere specified or included; illuminated signs, illuminated nameplates and the like; prefabricated buildings
95	Toys, games and sports requisites; parts and accessories thereof
96	Miscellaneous manufactured articles
97	Works of art, collectors' pieces and antiques
99	Other

Table A.8: 2-digit level HS Codes industries

Variable	Mean	Std. Dev.	Min.	Max.	N
Economic state of household	6.171	1.467	1	10	11541
Age of the respondent	44.763	16.167	15	94	11541
Female respondents	0.421	0.494	0	1	11541
Consumption of households	1075283.768	608788.448	167968	13672271	11541
Income of households	2137409.325	1204381.21	17144	20161000	11541

Table A.9: Summary statistics of households' datasets (D-002, D-003 and D-004) for 2018

Variable	Mean	Std. Dev.	Min.	Max.	N
Working hours	535057.671	1050898.095	40004	64140600	72270
Wage fund*	321359.090	1062708.288	7473.744	49618137.088	72270
Number of workers	301.338	617.22	100	40240	72270
Working days	69449.87	133312.149	6018	8024657	72270

*in thousands of 2009 Tenge

Table A.10: Summary statistics of firm-level labor data (1-T) from 2009-2017

Variable	Mean	Std. Dev.	Min.	Max.	N
Fixed assets at the begin. of a year	8882.782	199889.369	0	30320908.288	32879
Fixed assets at the end of a year	5156.533	80103.022	0	7151580.160	32879
Investments	944.433	18175.404	0	2593922.304	32879

in thousands of 2009 Tenge

Table A.11: Summary statistics of fixed assets (11) data from 2015-2018

Variable	Mean	Std. Dev.	Min.	Max.	N
Working hours	590983.225	2166684.45	1200	267451000	28867
Number of workers	340.518	827.234	100	40864	28867
Output	3703320.772	27531535.296	100	2053803648	28867
Fixed assets	3442842.184	29375951.301	0.548	1723772288	28867
Materials	1805765.923	9668756.954	4.387	319552672	28490
Investments	6339620.973	82915034.692	0	4973743104	6829

in thousands of 2009 Tenge

Table A.12: Summary statistics of firm level (1-PF and 1-T) data from 2009-2017

Variable	Freq.	Percent	Cum.
Agriculture	3,420	11.85	11.85
Mining	1,469	5.09	16.94
Manufacture	5,638	19.53	36.47
Utilities	2,048	7.09	43.56
Construction	4,225	14.64	58.20
Services	12,067	41.80	100.00
Total	28,867	100.00	

Servises are proxied as nontradables

Table A.13: Sectoral composition of firm level (1-PF and 1-T) data from 2009-2017