Essays on Tax Policies and International Trade

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Dedication

This dissertation is dedicated to my mom and dad. Thank you for standing by me at all times, loving and supporting me, believing in me, crying and laughing with me, being here for me, and now sharing with me the successful completion of this dissertation, my greatest achievement in life.

Abstract

After a decade of high growth, all segments of the Russian economy are experiencing a slowdown caused by the global financial crisis. Its structural weaknesses, high dependence on oil prices, absence of economic diversification, high taxes, administration barriers, corruption and high level of protectionism make the impact of the crisis more pronounced than otherwise. To boost growth and living standards, and to ensure that Russia emerges from this global crisis, the need for a correct and comprehensive economic policy response is of high importance these days.

This dissertation addresses two important economic issues in Russia: tax evasion and tariff reform. Though these topics have been studied intensively over the last century, there have been only a few attempts made in the economics field that give a direct estimate of tax evasion and tariff elimination for the Russian economy. The primary reason for preventing a direct estimate is a lack of reliable and representative data. This dissertation uses the most recent industry data from Russia not previously used and provides a theoretical and quantitative analysis of tax compliance and tariff reform in Russia.

The first chapter of this dissertation starts with an assessment of the role of taxation as a macroeconomic tool. It then reviews the problematic issues facing the tax system of developing countries such as tax evasion and tariff liberalization.

The second chapter explores tax compliance behavior of companies in Russia. I develop a static industry model of tax evasion with heterogeneous producers. The model is used to investigate the key determinants that give rise to tax evasion in Russia. Assuming that the probability of detection depends on the level of production, the model explains why small firms evade taxes. My quantitative experiments allow me to estimate how much the model economy gains if the tax burden, penalties, and probability of detection were changed. The results show that there are large potential fiscal gains for the Russian government if it can increase tax compliance.

The third chapter discusses potential effects of trade liberalization on the Russian economy. I construct a static applied general equilibrium model and perform a series of numerical experiments, such as a partial and complete tariff elimination scenario. To calibrate the model, I work with an input-output table of the most recent available year, 2003, and construct a social accounting matrix with a greater degree of disaggregation than any such matrix in the existing literature on Russia's economy. I find that tariff elimination has a positive effect in terms of trade diversification but a negative effect in terms of consumer and social welfare. To compensate for the budget loss, the government could choose to impose either higher taxes on consumption or higher export taxes on foreigners. Both policies increase government welfare but decrease consumer and social welfare that in the long run might lead to bigger economic losses.

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Chapter 1

Introduction

The end of the Cold War and the break-up of the Soviet Union marked the beginning of a complete transformation of economic alliances all over the globe. With the international economic situation changing rapidly, transition and developing economies felt compelled to implement economic reforms with the objective to shifting towards trade and financial liberalization. An integral part of these macroeconomics reforms was tax reform.

Taxation is a powerful policy instrument used to raise revenue to finance government expenditure. But building an administratively feasible and efficient tax system is a complicated task. Taxes always create distortions. High tax rates provide incentives for individuals and firms to deliberately misrepresent their true earnings giving rise to fraud, tax evasion and corruption. Fraud, tax evasion, and corruption are particularly common in underdeveloped countries. The high scale of tax evasion decreases government revenue and causes serious damage to the public sector, threatening its capacity to finance public services and goods. Thus the need for increasing fiscal revenue through a reduction of tax evasion seems to be of special significance these days.

Economic liberalization brings new opportunities to developing countries. Reduction in trade barriers and the elimination of capital controls provides greater access to developed markets. But tariffs, inflation tax, and the printing of money are traditional sources of revenue for developing countries. Therefore, reducing tariffs and eliminating capital controls does impose a large initial burden on the government budget. When the revenue from these taxes drops due to globalization, the government must rely on alternative sources such as Values Added Taxes (VAT), income taxes, and sales taxes. It is, therefore, important to tackle this transition on theoretical and empirical grounds.

My dissertation analyzes the economic problems of tax evasion and tariff elimination. I focus on a theory that may be applied to any country. But because of the new and detailed data I have on Russian industries, I use Russia as a country of my research work. Despite the fact that there exist many theoretical and empirical studies on tax evasion and tariff elimination, there are only a few empirical works written about Russia. To the best of my knowledge, there is one study which measures tax evasion on an industry level in Russia. Maxim Mironov (2006) studied tax evasion across short-lived firms using banking transaction data for 2003-2004. The burden of tax instruments in Russia was also analyzed by Rutherford and Paltsev (1999). Their research was based on an unbalanced

1995 Russian input-output table with 9 sectors. Alekseev, Tourdyeva, and Yudaeva (2003) analyzed the abolishment of the trade barriers between the EU and the Central and Eastern European Countries (CEECs) for the Russian economy using a static multi-regional computable general equilibrium model with 15 production sectors for the year 2000. A lack of representative and reliable time-series and industry data makes it hard to do research on Russia.

My dissertation improves on existing literature on two dimensions. First, I build two general equilibrium models to study tax evasion and tariff elimination. Second, I calibrate both models based on the most recent Russian industry data. I use the micro-level data on 5537 Russian firms provided by ZAO “Russian investment corporation” to calibrate the parameters of my tax evasion model. Then I use an input-output matrix for 2003 to construct a social accounting matrix that allows me to measure gains from trade. My theoretical and detailed data result in the precise estimate of tax evasion and gains to trade liberalization in Russia yet produced.

Chapter 2 discusses the problem of tax evasion. After a review of the prominent theoretical studies, I develop a static industry model of tax evasion with heterogeneous producers. I look at the effects of tax rates, penalty costs, and the probability of getting caught on the size of tax evasion and tax revenue. I assume that the probability of tax detection depends on the level of production. If the firm’s production level is smaller than a predetermined level of output, then the firm is not going to be caught for tax evasion. Once the firm’s production exceeds the output threshold, the tax evading firm will be monitored and punished by the tax administration if caught. Under this assumption, I show that the firms that decide to evade taxes are small whereas large firms fulfill their tax obligations. I calibrate the model to Russia in 1998. To estimate the model, I use Goskomstat data, the World Bank data, and the micro-level data on 5,537 Russian firms provided by ZAO “Russian investment corporation.” Using the firm's level data, I construct the size distribution of Russian firms that allows me to visually identify predicted tax evading firms. I also invent a method that allows me to calibrate an effective tax rate. The model predicts that higher tax rates as well as low penalty costs and low probability of detection encourage the concealment of activity. Reducing penalty costs or reducing the lower bound of output at which the government identifies tax evaders increases the size of the informal tax evading sector. An increase in the probability of detection and penalty costs leads to a greater reduction in the size of tax evasion than a simultaneous increase in the probability of detection and decrease in tax rates.

Chapter 3 analyzes potential effects of trade liberalization reform proposed by international organizations that includes elimination of border taxes. With the use of a static applied general equilibrium (GE) model, I perform a series of numerical experiments, such as a partial and complete tariff elimination scenario. To calibrate the model, I work with an input-output (IO) table of the most recent year available, 2003, and construct a social accounting matrix (SAM) with a much higher degree of disaggregation and precision than any such matrix in the existing literature on Russia's economy. I find that tariff elimination reform has a positive effect in terms of trade diversification, but a negative effect in terms of consumer and social welfare. To compensate the budget loss, the government may choose to impose either higher taxes on consumption or higher export taxes on foreigners. Both policies increase government welfare but decrease consumer and social welfare leading to economic losses in the long run.

Chapter 2

A Model of Tax Evasion with Heterogeneous Firms

2.1 Introduction

Benjamin Franklin (1706-90) once wrote, "*In this world nothing is certain but death and taxes.*" This fatalistic and sardonic aphorism is used to say that there were two unavoidable things in life: death and taxes. It seems that in today's world only one of these things is certain and unavoidable. A high tax burden, high intensity of government regulation, high incidence of bribery, and a weak rule of law drive a number of individuals and firms into the shadow economy.

The methods by which individuals and firms reduce their tax liabilities take a variety of legal and illegal forms. Such methods are broadly classified as avoidance and evasion. Tax avoidance is any legal utilization of existing tax loopholes to lower taxes, such as worker substitution between wage and nonwage compensation. Tax evasion is any illegal activity whereby individuals or firms deliberately conceal their true income to reduce tax liabilities. It includes dishonest tax reporting such as declaring less income than actually earned or overstating deductions. In this study any legal economic activities which are not taxed or registered but would generally be taxable were they reported to the tax authorities will be viewed as tax evasion.

Tax evasion and corruption exist to some degree everywhere and is particularly acute in the developing and transition economies. Schneider (2005) makes an attempt to estimate the size of the shadow economy[1] across 145 countries around the world (including transition, developing and developed) over the period of 1999 to 2003. He finds that in 2002-2003 the smallest underground sector was observed in the United States, Switzerland, and Austria and varied between 8.4 – 10.0 percent of the official GDP. The central European countries (the Netherlands, France, Germany, and Great Britain) - countries with comparatively high tax morale and high expected punishment - had the underground sector between 12-17 percent of the official GDP. The Netherlands, Germany, Denmark, Belgium, and Italy have shadow economies nearly one-third as large as the officially measured GDP. The underground sector in transition countries like Russia, Moldova, Belarus, Ukraine, and Georgia – countries with a high tax burden and a

[1] Schneider and Enste (2000, p. 78) define the shadow economy as "all economic activities that contribute to the officially calculated (or observed) gross national product but are currently unregistered."

high level of corruption – have a shadow economy over one-half the size of the officially recorded GDP. Analyzing the growth of the size of shadow economy across countries, Schneider concludes that in developed countries the shadow economy tends to shrink over time while in developing and transition economies it gets larger and larger each year. It is thus clear that tax evasion is an issue of first importance in underdeveloped countries.

The reason for studying tax evasion is self-evident. First, tax evasion is important as it imposes a considerable burden on the government budget. Loyaza (1996) argues that an increase in the shadow economy leads to an increase in tax revenue loss and therefore causes serious damage to the public sector, threatening its capacity to finance public services and goods. Second, it places a disproportionate share of the tax burden on honest taxpayers, and, thereby, distorts economic decision-making. Therefore, the need for studying tax evasion seems to be of special significance these days.

There exists a number of theoretical, experimental, and empirical papers regarding tax evasion by individuals, however, research on tax evasion by businesses is surprisingly modest. We know little about how the level of non-compliance varies by firm size. The reasons are simple. First, there is a lack of data and credible methods to estimate tax evasion on the micro-level. Second, policies that identify evaders vary across countries. Tax authorities might believe that the rich are most likely to evade taxes. Or they might base their policy on some statistical hypothesis that, in the absence of any information about actual production, a firm with a low output is more likely to be an evader. Here I would like to find what types of firms, efficient or inefficient, easily get away with cheating. The need for a model which might capture the firm's tax compliance decision is indeed unquestionable.

In this chapter I propose a static heterogeneous-firm general equilibrium model of tax evasion where firms differ in their productivities, as in Melitz (2003) industry model. I assume that that the probability of tax detection depends on the level of production with large firms facing a higher probability of detection. This results in the situation where small firms evade taxes whereas large firms pay taxes.

I calibrate my model to the case of Russia where the problem of tax evasion is particularly acute. There is a widespread perception among taxpayers in Russia that they do not owe the government anything because the government doesn't do anything for them, and so they evade taxes. Nearly half of the taxes owed in Russia never get paid. The Russian government is keen to maximize its tax revenue from all sources, as its budget is under extreme pressure. In 1998, tax chief Boris Fyodorov announced that he would target the rich individuals, adjusting tax focus on large enterprises such as the oil companies. The government tried to squeeze more revenue from the large domestic companies by removing all the tax privileges previously available under the Russian law. Targeting the high profile individuals, the Russian government was aiming to send a message to all Russians who considered evading taxes and encouraged them to start paying taxes.

I use Goskomstat data, the World Bank data, and the Russian firm-level data provided by ZAO "Russian investment corporation" to calibrate the parameters of my model. The firm data has statistical budget reports over the period of 1997 through 1999 for 49,829 Russian firms. I choose the year of 1998 and have 5,537 firms in my sample. I construct a method to identify tax evaders/tax payers and determine the effective payroll tax rate. I do a series of comparative statics experiments to quantitatively investigate the firms' choice to pay or not pay taxes in response to changes in the tax burden, tax evasion penalties, and probability of detection.

The results show that a decrease in the tax rate will always increase the reported income and decrease tax evasion. An increase in the penalty rate also induces tax compliance having all other parameters fixed. A small increase in the probability of detection at first increases a fraction of tax evaders who fix their output at a lower predetermined level of output to evade high payroll costs, but as it becomes larger, fewer firms choose to go underground. A large percentage change in the probability of detection, high penalty costs, and a low tax rate help to fight tax evasion.

Chapter 2 is divided as follows: Section 2.2 reviews the literature on tax evasion; Section 2.3 describes the data; Section 2.4 describes the model of tax evasion in which small-sized firms evade taxes, the agents' optimal behavior, and defines the competitive equilibrium allocations; Section 2.5 shows how to calibrate the model, discusses the case of Russia in 1998, and solves the model numerically. Finally, Section 2.6 provides some concluding remarks and policy implications. The appendix contains graphs and tables.

2.2 Theoretical Literature

In this section I will review the classic theoretical literature and empirical studies on tax evasion and discuss the main implications and findings. I will discuss static models, the main methods to estimate the size of tax evasion and identify the key determinants of tax evasion behavior.

In the early 1900s, tax evasion as a topic for theoretical investigation was in fact neglected and primarily considered by sociologists and anthropologists. Only in the 1950s and 1960s did economists start to show interest to the activities carried out outside the formal framework of the economy. Many have been trying to analyze the behavior of economic agents who engage in illegal activities and the incentives encouraging them to do so by developing formal models and applying them to a variety of socioeconomic problems, such as tax evasion. Yet there persist contradictions and inconsistent outcomes among research studies about tax evasion estimation procedures and the use of estimates in economic analysis and policy.

The classic paper on tax evasion was written by Allingham and Sandmo (1972), hereafter "A. and S." They assume that the taxpayer is faced with the decision of whether to pay taxes or to evade taxes. They choose an amount of income to declare so as to maximize the *von Neumann-Morgenstern* (VNM) expected utility function:

$$E[U] = (1-p)U(W-\theta X) + pU\big(W-\theta X - F(W-X)\big),$$

where W is the actual income[2], θ is the income tax rate, p is the probability of detection, X is the amount of declared income, F is the fine rate levied on the amount of concealed income that equals $W-X$. The comparative static analysis of A. and S.'s model implies that an increase in the penalty rate F and/or an increase in the probability of detection p will always increase the reported income X and so decrease tax evasion. However, an increase in the tax rate has an ambiguous effect on the incentives to cheat due to the competing income and substitution effects. On the one hand, an increased tax rate has a positive substitution effect since higher tax rate means greater marginal benefit of cheating, and this leads to more evasion. On the other hand, an increased tax rate has a

[2] Actual income is exogenously given and known by the taxpayer but not by the tax collector (Allingham and Sandmo, 1972, p. 324).

negative income effect since taxpayers feel less wealthy, therefore, providing decreasing absolute risk aversion, this effect alone would reduce evasion. Both the substitution and income effects compete against each other and thus it is impossible to say a priori whether higher taxes encourage or discourage dishonesty.

Kolm (1973) described the income tax evasion problem by setting up two separate problems: the taxpayer's problem and the government's problem. The taxpayer's problem is similar to the one described by A. and S. with the only difference that here the utility of taxpayer is represented by the expected utility from both the private goods and the public goods:

$$S = (1-p)U\left(W-\theta X\right) + pU\left(W-\theta X - F\left(W-X\right)\right) + V\left(T\right),$$

where W is the actual income, θ is the income tax rate, p is the probability of detecting fraud, X is the amount of declared income, F is the penalty rate on unreported income, and $V\left(T\right)$ is the utility of public goods, where T is the total tax yield used to produce public goods.

He assumes that citizens cannot affect the provision of public goods, so to a single citizen T is given. Hence, the public goods-driven utility can be ignored in the decision-making. So the taxpayer's problem looks exactly as in A. and S.'s model: Given the income tax rate, θ, the penalty rate, F, and the probability of detection, p, the taxpayer chooses X so as to maximize his expected utility EU of S:

$$EU = (1-p)U\left(W-\theta X\right) + pU\left(W-\theta X - F\left(W-X\right)\right).$$

Given the optimal taxpayer's decision, the government chooses parameters θ, p, and F to maximize S. Assuming that the taxpayers are identical in their preferences, S multiplied by the number of citizens gives the sum of the citizen's utilities. By separately solving the taxpayer's and the government's problems, and then comparing the resulting conditions simultaneously, Kolm concludes that "for ex ante public choices, a public pound has a higher social value that a private pound": (Kolm, p. 269)

$$U'\left(W-\theta X\right) < EU' < V' < U'(W-\theta X - F(W-X)).$$

The optimal values for the tax rate θ, the probability of fraud detection p, and the penalty F are determined by a balance between the utilities of public and private goods.

Srinivasan (1973) relaxed the constant tax rate assumption and introduced the proportionate tax $\theta(W)$ as a function of true income W. It is assumed that $\theta(W) > 0$, $0 < \theta'(W) < 1$, and $\theta''(W) \geq 0$; that is, $\theta(W)$ is positive, increasing, and convex function of W. If $\theta''(W) = 0$ for all W, we get a constant marginal tax rate which together with $\theta(0) = 0$ will yield a proportionate rate of tax. If $\theta''(W) > 0$ for all W, we get a progressive tax structure. The taxpayer chooses the proportion of income, λ, to be understated. The penalty parameter $F(\lambda)$ is endogenous and is imposed on the evaded income λW as in A. and S.'s model.

The individual taxpayer chooses the proportion λ so as to maximize his expected income after tax and penalties:

$$E(W) = (1-p)\left[W - \theta\left((1-\lambda)W\right)\right] + p\left[W - \theta(W) - F(\lambda)\lambda W\right].$$

After showing the existence and uniqueness of the optimal proportion λ^*, Srinivasan derives three main results. The first result states that if the probability of detection p increases, the optimal proportion λ^* by which income is understated decreases, i.e. $\partial\lambda^*/\partial p < 0$. The second results says that given a progressive tax function $\theta'' > 0$ and a probability of detection p *independent* of income, the more income a person generates, the large is the optimal proportion by which he will understate his income, i.e. $\partial\lambda^*/\partial W > 0$. Finally, in the case where $p(W)$ is an increasing function of income, it is hard to say how λ^* will respond to changes in W without additional assumptions. Assuming a constant marginal tax rate and $p(W)$ an increasing function of income, the optimal proportion λ^* decreases as income increases, i.e. $\partial\lambda^*/\partial W < 0$.

Pencavel (1979) continues to examine the effect of increases in the tax parameters and gross income on the income reporting decisions. He defines a von Neumann-Morgenstern utility function be a function over total income Y and hours of work h, i.e. $U(Y,h)$. Such an assumption illustrates how the tax system can affect not only people's decision to declare income but also their labor-leisure choice. The individual's actual tax payments given by T are approximated by a linear continuous function of the form:

$$T = -S + \theta X^{\sigma},$$

where S measures welfare payments from the government to individuals with zero income, X is the income the individuals report to the tax authorities, θ and σ are the parameters capturing the relationship between changes in reported income and changes in tax payments. The existing literature on tax evasion up to date has only analyzed the case of both $S = 0$ and $\sigma = 1$. The penalty function takes two forms: one is a heavy fine and/or imprisonment plus the payment of the evaded taxes; and the other is some fixed multiplier $\lambda > 1$ on the evaded tax payments. The individual makes a simultaneous ex ante decision of how much income to declare to the authorities and how many hours to work. He selects X and h so as to maximize the expected utility

$$EU(Y,h) = (1-p)U(Y^0,h) + pU(Y^c,h)$$

subject to

$$Y^0 = W(h) + S - \theta X^{\sigma}$$

$$Y^c = W(h) + S - \theta X^{\sigma} - \begin{cases} \theta\left(W^{\sigma} - X^{\sigma}\right) - F \\ \lambda\theta\left(W^{\sigma} - X^{\sigma}\right) \end{cases},$$

where Y^0 is the individual's net income when he underreports his income but not caught by the authorities, Y^c is the taxpayer's net income when he is caught cheating on his income taxes and then penalized with the fine, and p is the probability of being audited independent of the decision variables and given the individual's true taxable income $W(h) = wh + I$, where w is the gross hourly wage rate and I is nonwage income. He considers two scenarios: one is when hours of work is fixed which makes true income be exogenous, and the other is when hours of work are made endogenous.

The first results suggest that when true income is held fixed (h is fixed) and the risk aversion is a decreasing function of income, an increase in the tax parameters θ and σ, in the probability p of being audited and in the penalty multiplier λ increases reported income and lowers evasion. Increases in the level of welfare grants S increases after-tax wealth and induces a lower level of reported income. Finally, an increase in exogenous true taxable income W induces a fall in the fraction of income declared.

When true income becomes an endogenous variable (h is variable), an increase in the tax parameters may induce some ambiguities. For instance, an increase in the penalty rate λ may reduce hours of work which causes a decline in true income which may encourage the taxpayer to report less income to the authorities. An increase in σ and θ may also reduce hours of work and thus may reduce true income which may encourage the individual taxpayer to report less income to the tax authorities. In other words, the ambiguities in results derive from induced changes in hours of work and thus true taxable income.

Christiansen (1980) builds a simple theoretical model of tax evasion to analyze whether a large fine (with small probability of detection) is a more effective policy instrument to deter tax evasion than a high probability of detection (with a small penalty). Let X be the post-tax income if there is no evasion and Y be the unreported income. The disposable income will then become $X+Y$. If detected the tax evader will have to pay a fine of F times the hidden income. The probability of being detected p is a function of F. Given X, p and F, the individual chooses the value of Y to maximize

$$E=(1-p)U(X+Y)+pU(X-FY).$$

Let $U_s=U(X+Y)$ and $U_f=U(X-FY)$. The first- and second-order conditions for an interior solution are

$$E'=pU_s'-(1-p)U_f'=0,$$

$$E''=pU_s''+(1-p)F^2U_f''<0.$$

Using the maximum conditions, Christiansen finds

$$\frac{dY}{dF}=\frac{-1}{E''}\left[-(1-p)U_f'+(1-p)FYU_f''+\left(U_s'+FU_f'\right)\frac{dp}{dF}\right].$$

To analyze the effect of changes in F and p on Y, he defines two alternative relationships between F and p:

$1-p-pF=$ constant

and

$$pF=\text{constant.}$$

The first relationship implies that for a given tax evasion the expected gain given by $pY-(1-p)FY$ is constant and $dp/dF=(1-p)/(1-F)$. When risk aversion is assumed, $U''<0$, it implies

$$\frac{dY}{dF}=\frac{1-p}{E''}\left[\frac{U_f^{'}}{1+F}-\frac{U_s^{'}}{1+F}-FYU_f^{''}\right]<0$$

This result shows that an increase in the penalty rate will discourage tax evasion given that the probability of detection is adjusted to keep the expected gain unchanged. It follows that large fines are more effective to deter tax evasion than a high probability of detection.

Cowell (1985) investigates the phenomenon of "off the books" activities (Cowell, p.20). The individual in his model cheats the government by taking one or more different jobs the income from which is hard to observe and thus tax. Assume that there are three possible choices the person can make: work 'on the books', work 'off the books', and not to work and rest. Let h_0 and h_1 be the person's proportion of the time he spends in legal and illegal work, respectively. The time left for leisure is $1-H$,where $H=h_0+h_1$. The true legal wage rate is W_0 and illegal one is W_1. The government imposes a linear progressive tax system given by

$$T=\theta y_0-S,$$

where y_0 is taxable income, θ is the marginal tax rate, and S is a lump-sum grant. There are two states of the nature: successful evasion denoted by α, occurred with probability $(1-p)$, and unsuccessful evasion denoted by β, occurred with probability p. The penal rate is given by F. The person's disposable income c in the two states is given by c_α and c_β, respectively, where

$$c_\alpha=(1-\theta)W_0h_0+W_1h_1+S$$

and

$$c_\beta=(1-\theta)W_0h_0+(1-F)W_1h_1+S.$$

The individual chooses h_0 and h_1 to maximize

$$V=(1-p)U(c_\alpha,1-H)+pU(c_\beta,1-H)$$

subject to

$$c_\alpha = w_0 h_0 + W_1 h_1 + S$$

$$c_\beta = w_0 h_0 + w_1 h_1 + S \ ,$$

where $w_0 = (1-\theta)W_0$ and $w_1 = (1-F)W_1$.

Unlike previously discussed models on tax evasion, Cowell makes agents not to choose how much income to declare but how much time to allocate between legal and illegal activities and leisure. He claims that the fact that labor decisions are endogenous produces conflicting results and leads to no straightforward comparative statics conclusion. As long as U is additively separable in consumption and leisure and labor supply is backward-bending could he draw some conclusion about the level of evasion activity h_1. He concludes that if labor supply is backward bending, if absolute risk aversion is decreasing and relative risk aversion is increasing, then evasion activity increases with increases in θ.

Rausch (1991) looks at the relationship between the size of the informal sector and the minimum wage. His general equilibrium model, based on Lucas (1978) "span of control framework", suggests that entrepreneurs go underground to avoid minimum wage, which is greater than the paying market wage.

Dunn (1992) claims that the penalty for tax evasion would achieve only a modest change in tax compliance. Using Mexican data for 1982-89, his estimated results show that "a doubling of the fine for tax evasion would increase declared taxable income by about 10 percent" (Dunn, p.14).

Loayaza (1996) claim there are two types of regulations that influence the size of the informal labor market: red tape and taxes. Red tape and bureaucratic extortion (bribing) make starting a new business officially an unattractive option and can lead new firms to the informal sector. But taxes and redundancy pay make official firms offer lower wages which drives potential employees away into underground jobs. Depending on various combinations of policy parameters equilibria with different share of the informal economy are possible. The paper draws conclusions regarding the role of unemployment benefits in reducing the size of the informal economy and offers policy implications.

Djankov et al. (2002) analyze the consequences of the regulation of entry in 85 countries. They describe legal procedures to start up a business, as well as the official time and the official cost of meeting these procedures. Their theory of regulatory entry predicts that stricter regulation of entry is associated with sharply higher corruption and larger unofficial economies, but not better quality products. Countries with more democratic and limited governments have lighter regulation of entry.

Antunes and Cavalcanti (2006) build a model in which the agents choose the sector – formal or informal – to operate in. Those who choose to operate formally face the trade-off between the entry costs and the benefit of a better access to credit institutions. They apply their model to explain the observed differences in the size of informal sector between the United States and a Southern European country[3] and the Peruvian economy[4]. They conclude that a way to reduce the informal sector size in the Southern European economy would be to lower the regulation costs such as taxes, legal fees, bribes, and other implicit costs. As they lower the regulations costs the entrepreneurs bear, more entrepreneurs find it profitable to switch to the formal sector. The access to credit institutions enables them to expand their business even further. This, in turn, increases labor demand and the wage rate. Higher wages encourages some entrepreneurs to leave their current positions and become workers. As a result, the informal sector shrinks. However, for developing countries, both the barriers to entry and the level of contract enforcement have comparable importance in shifting a firm activity from the informal to the formal sector.

The models in this section are all static by nature. They attempt to answer the question of how much income the individuals decide to reveal to the authorities in the face of the known penalties and the known possibility of being detected. They analyze the effects of tax parameters, the structure of penalties, and the probability of being detected on the amount of tax evasion. The results state that an increase in the penalty rate and/or the probability of detection will increase the proportion of income declared and reduce tax evasion.

[3] The Southern Europe economy is a synthesis of the economies of Italy, Portugal and Spain.
[4] The Peruvian economy epitomizes Latin-American economies.

2.3 Data

From late 1998 to mid-2000 the World Bank sponsored personal interviews with managers of more than 10,000 enterprises in 80 countries covering the main regions of the world – The World Business Environment Surveys (WBES). The WBES uses a uniform core questionnaire to registered businesses to capture companies' perceptions of key constraints in the business environment posed by taxation, government regulations, corruption of public officials, functioning of the judiciary, and access to financial surveys. A more detailed description of the survey can be found in Batra et al. (2003).

Of interest to this study, the survey included a question regarding the extent and intensity to which firms fail to report income to the tax authority, which permits studies exploring the links between tax non-compliance and various firm characteristics. Specifically, the managers were asked, "Recognizing the difficulties that many firms face in fully complying with taxes and regulations, what percent of total annual sales would you estimate the typical firm in your area of business reports to tax authorities?" There were seven possible answers: 1 = all (100%), 2 = 90-99%, 3 = 80-89%, 4 = 70-79%, 5 = 60-69%, 6 = 50-59%, and 7 = less than 50%. The distribution of answers to the sales reporting question over the entire sample is given in Table 2.1.

As Table 2.1 shows, underreporting was clearly perceived to be greater among small firms than medium-size and large firms. Only 25.8 percent of small firms said that firms like them report 100 percent of sales (or income). The conclusion is that around the world informality is negatively associated with firms' productivity and their size.

2.4 Model

In this section I introduce a static model of tax evasion. This model incorporates the assumptions of product differentiation and firm productivity heterogeneity using the monopolistic competition framework proposed by Melitz (2003).

Consider an economy with a continuum of mass one of identical consumers-workers, each of whom is endowed with $\bar{l}$ units of labor. There is a measure of n potential firms. The representative consumer derives utility from the consumption of the differentiated goods according to a symmetric CES utility function. There is a continuum of the differentiated goods. Each variety is produced by a single firm. Firms differ ex-ante only in their labor productivities indexed by $x \in X$ (which is also used as the index for varieties). Firm productivities are distributed on the interval $x \geq 1$ according to the Pareto distribution with distribution function given by Eq. (2.1)

$$F(x) = 1 - x^{-\gamma}, \tag{2.1}$$

which has the density function given by Eq. (2.2)

$$f(x) = \gamma x^{-\gamma-1} \tag{2.2}$$

In other words, I suppose that the probability density function (p.d.f) of a random variable X with a continuous distribution is

$$f(x) = \begin{cases} \gamma x^{-\gamma-1} \text{ for } x \geq 1 \\ 0 \quad\quad \text{otherwise} \end{cases}, \tag{2.3}$$

where shape parameter $\gamma > \sigma - 1$.

Firms in the economy face two decisions: produce or shut down, pay or evade taxes. The timing of the firm's decisions is as follows. An entering firm first invests a fixed entry-cost f to receive efficiency x. (Notice that firms have potentially different productivity levels x). After x is revealed, a firm may decide to shut down and incur no further costs. If the firm decides to produce then it may choose to continue with future production and either pay taxes or evade taxes. Once the decision is made, it cannot be altered. Legal firms are subject to a payroll tax, τ. For each dollar of gross income, then, an honest firm would receive $(1-\tau)$ dollars. If the firms were dishonest, did not pay tax liabilities and escaped detection, would receive 1 dollar. But if they got caught, they would face a fixed penalty ζ associated with tax regulations.

2.4.1 Consumers

Let $\bar{x}$ be the minimal cutoff productivity level such that any entering firm drawing a productivity level $x < \bar{x}$ will immediately exit and never produce. Once the firm enters the market with efficiency level $x \geq \bar{x}$, it produces a final good $c(x)$ to satisfy consumers' demand. The representative consumer derives utility from consumption according to the logarithmic CES Dixit-Stiglitz utility function of the form given by Eq. (2.4):

$$U = \log\left(n\int_{\bar{x}}^{\infty} c(x)^{\rho}\, dF(x) \right)^{1/\rho}, \tag{2.4}$$

where the parameter ρ , $0 < \rho \le 1$, governs the elasticity of substitution $1/(1-\rho)$ between any two differentiated consumption goods. The consumer faces the following budget constraint given by Eq. (2.5):

$$n\int_{\bar{x}}^{\infty} p(x)c(x)\,dF(x) = w\bar{l} + \Pi + R, \tag{2.5}$$

where $c(x)$ is consumption goods produced by firms with productivities levels $\bar{x} \le x < \infty$ and $p(x)$ is the price charged by the firms. The consumer supplies $\bar{l}$ units of labor at the nominal wage rate, w. In addition to labor income, the consumer receives the profit flows Π of firms and the lump-sum transfers R. Both the aggregate profits Π and lump-sum transfers R are rebated equally to all consumers. The consumers' ownership of the firms is modeled as passive, in that they take the profit rebate as given. Similarly, the lump-sum transfers R are given too.

The consumer's problem is to choose $c(x)$ to maximize Eqs. (2.4) subject to (2.5). The first order conditions of this problem include Eqs. (2.6) to (2.7):

$$c(x') = \left(\frac{p(x')}{p(x)} \right)^{\frac{1}{\rho-1}} c(x), \tag{2.6}$$

$$n\int_{\bar{x}}^{\infty} p(x)c(x)\,dF(x) = w\bar{l} + \Pi + R. \tag{2.7}$$

The solution to the maximization problem of the consumer gives rise to the usual CES Dixit-Stiglitz demands for each x according to Eq. (2.8):

$$c(x) = \frac{w\bar{l} + \Pi + R}{p(x)^{\frac{1}{1-\rho}} P^{-\frac{\rho}{1-\rho}}}, \tag{2.8}$$

where Π, R, and P are the aggregate profit, aggregate transfer flows, and overall price level, respectively.

In an equilibrium characterized by a mass n of firms (and hence n goods) and a distribution $f(x)$ of productivity level over a subset of $(\bar{x}, \infty)$, the aggregate price level P can be found by solving a cost minimization problem of acquiring one unit of aggregate consumption good given by Eqs. (2.9) to (2.10):

$$\min\left[n\int_{\bar{x}}^{\infty} p(x)c(x)dF(x) \right] \tag{2.9}$$

subject to

$$\left(n\int_{\bar{x}}^{\infty} c(x)^{\rho}\, dF(x) \right)^{1/\rho} = 1 \tag{2.10}$$

The aggregating price level derived from Eqs. (2.9) and (2.10) is given by Eq. (2.11):

$$P^{-\frac{\rho}{1-\rho}} = \left(n\int_{\bar{x}}^{\infty} p(x)^{\frac{\rho}{\rho-1}}\, dF(x) \right) \tag{2.11}$$

2.4.2 Firms

In this section, I specify the maximization problems of the firms in the economy and characterize their solutions. Production involves a fixed and variable cost each period. At the beginning of a period, each firm chooses its labor input. Labor is the only factor of production, and I normalize the wage level to unity. Firms produce with a technology exhibiting constant marginal cost $1/x$, along with an overhead per-period fixed cost f (measured in labor units). Given the direct demand and a continuum of competing firms, all firms set a constant markup $\sigma/(\sigma-1)$ over marginal cost. The technology used by a firm with efficiency x combines labor inputs l to produce output y according to Eq. (2.12):

$$y(x) = \max\left[x\left(l(x) - f\right), 0 \right]. \tag{2.12}$$

Here $f > 0$ is the level of fixed labor costs. Production then occurs, and each firm chooses whether to pay taxes or evade them.

2.4.2.1 Taxpayer Firms

The profit maximization problem of a taxpayer firm with efficiency x is given by Eq. (2.13) subject to Eq. (2.14):

$$\pi^T\left(y^T(x)\right)=\max\left[p^T(x)y^T(x)-(1+\tau)wl^T(x)\right] \tag{2.13}$$

subject to

$$y^T(x)=\max\left[x\left(l^T(x)-f\right),0\right] \tag{2.14}$$

Here $l^T(x)$ and $y^T(x)$ denote the amount of labor and output of the taxpayer firm, respectively. The payroll tax rate is indexed by uniform payroll tax rate, τ. It is clear that an operating firm would choose $y^T(x)=x\left(l^T(x)-f\right)$. Using market clearing condition, we know that $y^T(x)=c^T(x)$. Given the direct demand function $c^T(x)$ that comes from the consumer's problem, the profit maximization problem can be re-written as shown in Eq. (2.15):

$$\max_{p^T(x)} p^T(x)c^T(x)-(1+\tau)w\left(\frac{c^T(x)}{x}+f\right). \tag{2.15}$$

Assume that the wage rate w is equal to one. This yields an optimal pricing rule for $c^T(x)$ is:

$$p^T(x)=\frac{1+\tau}{\rho x}. \tag{2.16}$$

Equation (2.16) illustrates the fact that among tax payers a more productive firm (higher x) will be bigger, charge a lower price, and earn higher profits than a less productive firm.

2.4.2.2 Non-taxpayer Firms

Here, I describe the profit maximization problem for a non-taxpayer firm with efficiency x. I assume that the probability of being monitored depends monotonically on the size of the firm. There are several possibilities for measuring the size of the firm – output, labor force, or productivity level. Here I choose to use the firm's output. Let the probability of being detected $1-\mu\left(y(x)\right)$ is defined by Eq. (2.17):

$$1-\mu\left(y(x)\right)=\begin{cases}0 & \text{if} \quad y(x)\le \bar{y}_L \\ 1-\bar{\mu} & \text{if} \quad \bar{y}_L < y(x)\le \bar{y}_H \\ 1 & \text{if} \quad y(x) > \bar{y}_H\end{cases}, \tag{2.17}$$

where $0<\bar{\mu}<1$, $\bar{y}_L$ and $\bar{y}_H$ are the low and high exogenously given levels of output that the government sets for its monitoring purposes. The functional form is chosen so that the firms producing less than of equal to $\bar{y}_L$ decide to evade taxes since they know they won't be monitored. It is costly for the government to monitor and prosecute small firms. The firms with productivity levels $y(x)$ such that $y(x)>\bar{y}_L$ and $y(x)\le\bar{y}_H$ produce the final output $y(x)$ and face a constant chance of being caught, expressed as $1-\bar{\mu}$. Lastly, when the firm's production exceeds $\bar{y}_H$, the evading firm will certainly be caught by the authorities for tax evasion, thus such firms pay all taxes.

The non-taxpayer sets its price $p^{NT}(x)$ to solve the profit maximization problem given by Eq. (2.18) subject to Eq. (2.19):

$$\max_{p^{NT}(x)} p^{NT}(x)\,y^{NT}(x)-w\left[\frac{y^{NT}(x)}{x}+f\right]-\left(1-\mu\left(y(x)\right)\right)\left[\tau w\left(\frac{y^{NT}(x)}{x}+f\right)+\zeta\right] \tag{2.18}$$

subject to

$$y^{NT}(x)=\max\left[x\left(l^{NT}(x)-f\right),0\right] \tag{2.19}$$

If caught, non-taxpayer will face a fixed cost ζ associated with operating illegally as well as payments of taxes owed. Analogously, the direct demand function $c^{NT}(x)$ that comes from the consumer's problem is equal to $y^{NT}(x)$ by market clearing condition. Using Eq. (2.8) and solving the maximization problem described above, I find the optimal pricing rule for the non-taxpayer is:

$$p^{NT}(x)=\frac{1+\left(1-\mu\left(y^{NT}(x)\right)\right)\tau}{\rho x} \tag{2.20}$$

As in Eq. (2.16), the pricing rule $p^{NT}(x)$ is inversely related to the efficiency level. The only difference is that tax evaders that are not monitored by government officials are no longer subject to taxes. . It allows them to charge lower price $\frac{1}{\rho x}$ and earn higher profits than tax payers. Once the firms start to get monitored with probability $1-\overline{\mu}$, Eq. (2.20) becomes of the form:

$$p_{\overline{\mu}}^{NT}\left(x\right)=\frac{1+\left(1-\overline{\mu}\right)\tau}{\rho x}, \tag{2.21}$$

as written in Eq. (2.21).

2.4.3 Efficiency and Decision-Making

This section determines the crucial elements of the model such as the cutoff productivity levels for entry-exit and tax evasion decisions. I will discuss each one separately.

2.4.3.1 Efficiency and Entry-Exit Decision

Each industry has multiple potential producers of each good with varying level of efficiency x. Except for this heterogeneity in efficiency, the production technology is identical across producers wherever and whatever they produce. Prior to entry, firms are identical. To enter, firms must first pay a fixed entry cost $f>0$ in units of labor costs. Firms then draw their initial productivity parameter x from a Pareto distribution $f\left(x\right)$ given by Eq. (2.3). If the firm draws a low productivity draw, it immediately exits. Assume that $\overline{x}_1^{NT}$ is the productivity cutoff level for operating firms. If the firm produces, its productivity level is $x \geq \overline{x}_1^{NT}$. This simplification highlights the fact that new entrants will experience, on average, lower productivity and a higher probability of exit than incumbents.

Any entering firm with productivity x would immediately exit if it earns a negative profit $\pi\left(x\right)<0$. No firm would want to enter if the value were negative. All other incumbent firms would produce and earn $\pi\left(x\right)\geq 0$. Assume that the cutoff firm drawing the smallest productivity level $\overline{x}_1^{NT}$ is not monitored by the tax administration (meaning $\mu\left(y^{NT}\left(\overline{x}_1^{NT}\right)\right)=1$) and earn a zero profit. Then the productivity cutoff level $\overline{x}_1^{NT}$ is then determined by the zero cutoff profit condition given by Eq. (2.22)

$$\pi^{NT}\left(y^{NT}\left(\overline{x}_1^{NT}\right)\right)=0\,. \tag{2.22}$$

It implies that

$$\overline{x}_1^{NT}=\left(\frac{fn\gamma\Phi}{(1+\tau)^{\frac{\rho}{1-\rho}}(wl+\Pi+R)\left(\gamma(1-\rho)-\rho\right)}\right)^{\frac{1-\rho}{\rho}}, \tag{2.23}$$

where

$$\Phi=(1+\tau)^{\frac{\rho}{1-\rho}}\left[\left(\overline{x}_1^{NT}\right)^{v}-\left(\overline{x}_2^{NT}\right)^{v}\right]+\frac{\gamma(1-\rho)-\rho}{\gamma(1-\rho)}\left((1+\tau)\overline{x}_2^{NT}\right)^{\frac{\rho}{1-\rho}}\left[\left(\overline{x}_2^{NT}\right)^{-\gamma}-\left(\overline{x}_1^{T}\right)^{-\gamma}\right]+$$
$$\left(\frac{1+\tau}{\psi}\right)^{\frac{\rho}{1-\rho}}\left[\left(\overline{x}_1^{T}\right)^{v}-\left(\overline{x}_2^{T}\right)^{v}\right]+\frac{\gamma(1-\rho)-\rho}{\gamma(1-\rho)}\left(\frac{(1+\tau)\overline{x}_2^{T}}{\psi}\right)^{\frac{\rho}{1-\rho}}\left[\left(\overline{x}_2^{T}\right)^{-\gamma}-\left(\overline{x}\right)^{-\gamma}\right]+\left(\overline{x}\right)^{v}$$

and $\psi=1+\left(1-\overline{\mu}\right)\tau$ and $v=\rho/(1-\rho)-\gamma$. Equation (2.23) says that any firm drawing a productivity level $x<\overline{x}_1^{NT}$ will immediately exit and never produce. Any firm with $x\geq\overline{x}_1^{NT}$ would enter and produce. We can also see that the first cutoff threshold is negatively correlated with taxes: the higher the tax rate, the lower the threshold will become, the more small firms decide to enter and go underground. However, the higher the entry costs f, the lower the threshold will become, the less firms enter the market.

2.4.3.2 Efficiency and Tax Evasion Decision

Any operating firm always seeks to maximize its profits. It follows the same rule even when deciding whether to pay or evade taxes. In this paper I assume that greater production outcome raises the probability of detection. If a firm's production level $y(x)$ has exceeded a pre-determined level of $\overline{y}_L$, there is a $1-\overline{\mu}$ - percent chance of being monitored by the government. If so, the firms with productivity levels x such as

$x \geq x_1^{NT}$ and $x \leq x_2^{NT}$ produce $y^{NT}(x)$ given by $\dfrac{w\bar{l} + \Pi + R}{p^{NT}(x)^{\frac{1}{1-\rho}} P^{-\frac{\rho}{1-\rho}}}$ and face no risk to be caught for tax evasion. The model become less trivial when firms reach the first critical threshold $\bar{x}_2^{NT}$ that corresponds to the production level $\bar{y}_L$. The firms with productivity levels x such as $x > \bar{x}_2^{NT}$ and $x \leq \bar{x}_1^{T}$ can potentially produce more than $\bar{y}_L$ and face a $1 - \bar{\mu}$ - chance to be caught for tax evasion. In this paper I will model the case when such firms decide to scale down their production and fix it exactly at $\bar{y}_L$ as if they were producers of type $\bar{x}_2^{NT}$ and charge a price $p^{NT}\left(\bar{x}_2^{NT}\right)$. By doing so, they avoid of being penalized for tax evasion. Since the firms' efficiency levels keep increasing on this interval, each firm is able to produce $\bar{y}_L$ with a fewer number of workers. A reduction in firms' employment level enables them to lower their payroll tax payments and a fixed price increases their operating revenues. The cutoff level $\bar{x}_2^{NT}$ is determined by Eq. (2.24):

$$\pi^{NT}\left(y^{NT}\left(\bar{x}_2^{NT}\right)\right) = \pi^{NT}\left(\bar{y}_L\right), \tag{2.24}$$

which is the same as $y^{NT}\left(\bar{x}_2^{NT}\right) = \bar{y}_L$.

Then the optimal cutoff rule implies

$$\bar{x}_2^{NT} = \left(\frac{\bar{y}_L n(1-\rho)\gamma\Phi}{(1+\tau)^{\frac{\rho}{1-\rho}} (wl + \Pi + R)\left(\gamma(1-\rho) - \rho\right)\rho} \right)^{1-\rho} \tag{2.25}$$

Equation (2.25) shows that the second cutoff level $\bar{x}_2^{NT}$ is also negatively correlated with the tax rate having all other factors fixed. But at the same we can see that it is positively correlated with the lower bound level $\bar{y}_L$. So the higher $\bar{y}_L$, the higher $\bar{x}_2^{NT}$, the higher percentage of small firms that decide to go underground.

The third cutoff level $\bar{x}_1^{T}$ is determined in a similar fashion but now the firm must be indifferent in profits between producing a fixed level $\bar{y}_L$ with a zero probability of being monitored and a level $y_{\bar{\mu}}^{NT}\left(\bar{x}_1^T\right)$ with a 1- $\bar{\mu}$ - chance to be caught. In other words, the threshold $\bar{x}_1^T$ is determined by the following condition:

$$\pi^{NT}\left(\bar{y}_L\right)=\pi_{\bar{\mu}}^{NT}\left(y_{\bar{\mu}}^{NT}\left(\bar{x}_1^T\right)\right), \tag{2.26}$$

where $y_{\bar{\mu}}^{NT}\left(\bar{x}_1^T\right)=\dfrac{(1+\tau)^{\frac{\rho}{1-\rho}}\left(w\bar{l}+\Pi+R\right)\left(\gamma(1-\rho)-\rho\right)\rho\left(\bar{x}_1^T\right)^{\frac{1}{1-\rho}}}{\psi^{\frac{1}{1-\rho}}n(1-\rho)\gamma\Phi}$.

Equation (2.26) can be re-written as follows:

$$p^{NT}\left(\bar{x}_2^{NT}\right)\bar{y}_L-\left(\frac{\bar{y}_L}{\bar{x}_1^T}+f\right)=$$

$$p^{NT}\left(\bar{x}_1^T\right)y^{NT}\left(\bar{x}_1^T\right)-\left(\frac{y_{\bar{\mu}}^{NT}\left(\bar{x}_1^T\right)}{\bar{x}_1^T}+f\right)-\left(1-\bar{\mu}\right)\left(\tau\left(\frac{y_{\bar{\mu}}^{NT}\left(\bar{x}_1^T\right)}{\bar{x}_1^T}+f\right)+\zeta\right). \tag{2.27}$$

Equation (2.27) implies

$$\bar{x}_1^T=\frac{\frac{1-\rho}{\rho}\psi\, y_{\bar{\mu}}^{NT}\left(\bar{x}_1^T\right)+\bar{y}_L}{\frac{1}{\rho\bar{x}_2^{NT}}\bar{y}_L+\left(1-\bar{\mu}\right)\left[\tau f+\zeta\right]}. \tag{2.28}$$

The fourth cutoff level $\bar{x}_2^T$ is such that the firm must be indifferent in profits between producing $y_{\bar{\mu}}^{NT}\left(\bar{x}_2^T\right)$ and producing a higher threshold level $\bar{y}_H$ with a $1-\bar{\mu}$ - probability of being caught in both cases. In other words, the threshold $\bar{x}_2^T$ is determined by the following condition:

$$\pi_{\bar{\mu}}^{NT}\left(y_{\bar{\mu}}^{NT}\left(\bar{x}_2^T\right)\right)=\pi_{\bar{\mu}}^{NT}\left(\bar{y}_H\right), \tag{2.29}$$

which is equivalent to $y_{\bar{\mu}}^{NT}\left(\bar{x}_2^T\right)=\bar{y}_H$.

Equation (2.29) implies

$$\bar{x}_2^T = \left(\frac{\bar{y}_H \psi^{\frac{1}{1-\rho}} n(1-\rho)\gamma\Phi}{(1+\tau)^{\frac{\rho}{1-\rho}} (wl + \Pi + R)(\gamma(1-\rho)-\rho)\rho} \right)^{1-\rho} . \tag{2.30}$$

Finally, the firms keep producing at $\bar{y}_H$ until the point when they get indifferent between not paying all taxes and being caught with a probability $1-\bar{\mu}$ and paying all taxes and produce at y^T. That can be written as

$$\pi_{\bar{\mu}}^{NT}\left(\bar{y}_H\right) = \pi^T\left(y^T\left(\bar{x}\right)\right), \tag{2.31}$$

where $y^T\left(\bar{x}\right) = \dfrac{\left(w\bar{l} + \Pi + R\right)\left(\gamma(1-\rho)-\rho\right)\rho\bar{x}^{\frac{1}{1-\rho}}}{n(1-\rho)\gamma(1+\tau)\Phi}$.

Equation (2.31) becomes

$$p_{\bar{\mu}}^{NT}\left(\bar{x}_2^T\right)\bar{y}_H - \left(\frac{\bar{y}_H}{\bar{x}} + f\right) - \left(1-\bar{\mu}\right)\left(\tau\left(\frac{\bar{y}_H}{\bar{x}} + f\right) + \zeta\right) =$$

$$p^T\left(\bar{x}\right)c^T\left(\bar{x}\right) - (1+\tau)\left(\frac{c^T\left(\bar{x}\right)}{\bar{x}} + f\right) \tag{2.32}$$

Thus, solving Eq. (2.32) the threshold $\bar{x}$ is given by Eq. (2.33)

$$\bar{x} = \left(\frac{n\gamma\Phi\left[\psi\left(\frac{1}{\rho\bar{x}_2^T} - \frac{1}{\bar{x}}\right)\bar{y}_H + (1+\tau-\psi)f - \left(1-\bar{\mu}\right)\zeta\right]}{\left(w\bar{l} + \Pi + R\right)\left(\gamma(1-\rho)-\rho\right)} \right)^{\frac{1-\rho}{\rho}} . \tag{2.33}$$

2.4.4 Aggregation

In equilibrium, the aggregate profit Π is given by Eq. (2.34)

$$\Pi = \Pi_1 + \Pi_2 + \Pi_3 + \Pi_4 + \Pi_5 , \tag{2.34}$$

where

$$\Pi_1 = n \int_{\bar{x}_1^{NT}}^{\bar{x}_2^{NT}} \pi^{NT}\left(y^{NT}(x)\right) dF(x) =$$

$$\frac{(1+\tau)^{\frac{\rho}{1-\rho}}\left(w\bar{l}+\Pi+R\right)(1-\rho)}{\Phi}\left[\left(\overline{x}_1^{NT}\right)^{v}-\left(\overline{x}_2^{NT}\right)^{v}\right]-nf\left[\left(\overline{x}_1^{NT}\right)^{-\gamma}-\left(\overline{x}_2^{NT}\right)^{-\gamma}\right];$$

$$\Pi_2=n\int_{\overline{x}_2^{NT}}^{\overline{x}_1^{T}}\pi^{NT}\left(\overline{y}_L\right)dF(x)=$$

$$n\left[\left(\frac{\overline{y}_L}{\rho\overline{x}_2^{NT}}-f\right)\left[\left(\overline{x}_2^{NT}\right)^{-\gamma}-\left(\overline{x}_1^{T}\right)^{-\gamma}\right]-\overline{y}_L\frac{\gamma}{\gamma+1}\left[\left(\overline{x}_2^{NT}\right)^{-(\gamma+1)}-\left(\overline{x}_1^{T}\right)^{-(\gamma+1)}\right]\right],$$

$$\Pi_3=n\int_{\overline{x}_1^{T}}^{\overline{x}_2^{T}}\pi_{\overline{\mu}}^{NT}\left(y_{\overline{\mu}}^{NT}(x)\right)dF(x)=$$

$$\frac{(1+\tau)^{\frac{\rho}{1-\rho}}\left(w\bar{l}+\Pi+R\right)(1-\rho)}{\psi^{\frac{\rho}{1-\rho}}\Phi}\left[\left(\overline{x}_1^{T}\right)^{v}-\left(\overline{x}_2^{T}\right)^{v}\right]-n\left[\psi f+\left(1-\overline{\mu}\right)\zeta\right]\left[\left(\overline{x}_1^{T}\right)^{-\gamma}-\left(\overline{x}_2^{T}\right)^{-\gamma}\right];$$

$$\Pi_4=n\int_{\overline{x}_2^{T}}^{\overline{x}}\pi_{\overline{\mu}}^{NT}\left(\overline{y}_H\right)dF(x)=$$

$$n\left[\left[\psi\left(\frac{\overline{y}_H}{\rho\overline{x}_2^{T}}-f\right)-\left(1-\overline{\mu}\right)\zeta\right]\left[\left(\overline{x}_2^{T}\right)^{-\gamma}-\left(\overline{x}\right)^{-\gamma}\right]-\psi\overline{y}_H\frac{\gamma}{\gamma+1}\left[\left(\overline{x}_2^{T}\right)^{-(\gamma+1)}-\left(\overline{x}\right)^{-(\gamma+1)}\right]\right];$$

$$\Pi_5=n\int_{\overline{x}}^{\infty}\pi^{T}\left(y^{T}(x)\right)dF(x)=$$

$$\frac{(wl+\Pi+R)(1-\rho)}{\Phi}\left(\overline{x}\right)^{v}-n(1+\tau)f\,\overline{x}^{-\gamma},$$

where $\pi^{NT}\left(y^{NT}(x)\right)$, $\pi^{NT}\left(\overline{y}_L\right)$, $\pi_{\overline{\mu}}^{NT}\left(y_{\overline{\mu}}^{NT}(x)\right)$, $\pi_{\overline{\mu}}^{NT}\left(\overline{y}_H\right)$, and $\pi^{T}\left(y^{T}(x)\right)$ are aggregate profits for non-taxpayers producing $y^{NT}(x)$, non-taxpayers producing $\overline{y}_L$, non-taxpayers producing $y_{\overline{\mu}}^{NT}(x)$ and being monitored with probability $1-\overline{\mu}$, non-taxpayers producing $\overline{y}_H$ and also being monitored with probability $1-\overline{\mu}$, and taxpayers producing $y^{T}(x)$, respectively. The first and second integrals measure the average profits of the tax evading firms which are not monitored and are the ones in the range of x starting from $\overline{x}_1^{NT}$ up to $\overline{x}_2^{NT}$ and from $\overline{x}_2^{NT}$ up to $\overline{x}_1^{T}$, respectively. The third and fourth integrals measure the average profits of the tax evading firms which are monitored with probability $1-\overline{\mu}$ and have efficiency levels x starting from $\overline{x}_1^T$ up to $\overline{x}_2^T$ and from $\overline{x}_2^T$ up to $\overline{x}$, respectively. Finally, the fourth integral measures the average profit of all firms that pay taxes with $x > \overline{x}$.

In equilibrium, the aggregate transfers R is given by Eq. (2.35)

$$R = R_1 + R_2 + R_3 + R_4 + R_5, \tag{2.35}$$

where

$R_1 = n\int_{\overline{x}_1^{NT}}^{\overline{x}_2^{NT}} r^{NT}\left(y^{NT}(x)\right)dF(x)$; $R_2 = n\int_{\overline{x}_2^{NT}}^{\overline{x}_1^{T}} r^{NT}\left(\overline{y}_L\right)dF(x)$; $R_3 = n\int_{\overline{x}_1^{T}}^{\overline{x}_2^{T}} r^{NT}\left(y_{\overline{\mu}}^{NT}(x)\right)dF(x)$;

$R_4 = n\int_{\overline{x}_2^{T}}^{\overline{x}} r^{NT}\left(\overline{y}_H\right)dF(x)$; and $R_5 = n\int_{\overline{x}}^{\infty} r^{T}\left(y^{T}(x)\right)dF(x)$. Notice that the expression inside the first integral given by $r^{NT}\left(y^{NT}(x)\right) = \left(1-\mu\left(y(x)\right)\right)\left[\tau w\left(y^{NT}(x)/x + f\right) + \zeta\right]$ stands for the amount of taxes the individual tax evader producing $y^{NT}(x)$ pays if caught. Similarly, the expression inside the second integral $r^{NT}\left(\overline{y}_L\right) = \left(1-\mu\left(\overline{y}_L\right)\right)\left[\tau w\left(\overline{y}_L/x + f\right) + \zeta\right]$ is the amount of taxes the firm with $\overline{y}_L$ pays if caught. The probability of tax detection in both cases is zero which leads to $R_1 = R_2 = 0$ as a result. The firms which produce more than $\overline{y}_L$ start to get monitored. Thus, the transfers R_3 become as follows

$$R_3 = \left(1-\overline{\mu}\right)\tau\frac{(1+\tau)^{\frac{\rho}{1-\rho}}\left(w\bar{l} + \Pi + R\right)\rho}{\psi^{\frac{1}{1-\rho}}\Phi}\left[\left(\overline{x}_1^T\right)^{\nu} - \left(\overline{x}_2^T\right)^{\nu}\right]$$
$$+ n\left(1-\overline{\mu}\right)\left[\tau f + \zeta\right]\left[\left(\overline{x}_1^T\right)^{-\gamma} - \left(\overline{x}_2^T\right)^{-\gamma}\right].$$

The transfers R_4 which are nothing but the tax revenue received from the firms producing at a level of $\overline{y}_H$ are given by:

$$R_4 = n\left(1-\overline{\mu}\right)\left[\tau\overline{y}_H\frac{\gamma}{\gamma+1}\left[\left(\overline{x}_2^T\right)^{-(\gamma+1)} - \left(\overline{x}\right)^{-(\gamma+1)}\right] + \left[\left(\overline{x}_2^T\right)^{-\gamma} - \left(\overline{x}\right)^{-\gamma}\right](\tau f + \zeta)\right].$$

Lastly, the expression $r^T(x)=\tau w\left(y^T(x)/x+f\right)$ is the regular tax payments paid by the honest firm. This will lead to

$$R_5=\frac{\tau\left(wl+\Pi+R\right)\rho}{\left(1+\tau\right)\Phi}\left(\bar{x}\right)^{\nu}+n\tau f\left(\bar{x}\right)^{-\gamma}.$$

In equilibrium, the aggregate price level P is given by Eq. (2.36)

$$P=\left(P_1+P_2+P_3+P_4+P_5\right)^{\frac{\rho-1}{\rho}}, \tag{2.36}$$

where

$$P_1=n\int_{\bar{x}_1^{NT}}^{\bar{x}_2^{NT}} p^{NT}(x)^{\frac{\rho}{\rho-1}}dF(x)=n\int_{\bar{x}_1^{NT}}^{\bar{x}_2^{NT}}\left(\frac{1}{\rho x}\right)^{\frac{\rho}{\rho-1}}\gamma x^{-\gamma-1}dx;$$

$$P_2=n\int_{\bar{x}_2^{NT}}^{\bar{x}_1^{T}} p^{NT}\left(\bar{x}_2^{NT}\right)^{\frac{\rho}{\rho-1}}dF(x)=n\int_{\bar{x}_2^{NT}}^{\bar{x}_1^{T}}\left(\frac{1}{\rho\bar{x}_2^{NT}}\right)^{\frac{\rho}{\rho-1}}\gamma x^{-\gamma-1}dx;$$

$$P_3=n\int_{\bar{x}_1^{T}}^{\bar{x}_2^{T}} p_{\bar{\mu}}^{NT}(x)^{\frac{\rho}{\rho-1}}dF(x)=n\int_{\bar{x}_1^{T}}^{\bar{x}_2^{T}}\left(\frac{1+\left(1-\bar{\mu}\right)\tau}{\rho x}\right)^{\frac{\rho}{\rho-1}}\gamma x^{-\gamma-1}dx;$$

$$P_4=n\int_{\bar{x}_2^{T}}^{\bar{x}} p_{\bar{\mu}}^{NT}\left(\bar{x}_2^{T}\right)^{\frac{\rho}{\rho-1}}dF(x)=n\int_{\bar{x}_2^{T}}^{\bar{x}}\left(\frac{1+\left(1-\bar{\mu}\right)\tau}{\rho\bar{x}_2^{T}}\right)^{\frac{\rho}{\rho-1}}\gamma x^{-\gamma-1}dx;$$

$$P_5=n\int_{\bar{x}}^{\infty} p^{T}(x)^{\frac{\rho}{\rho-1}}dF(x)=n\int_{\bar{x}}^{\infty}\left(\frac{1+\tau}{\rho x}\right)^{\frac{\rho}{\rho-1}}\gamma x^{-\gamma-1}dx.$$

The expressions for pricing rules give me the aggregate price level given by Eq. (2.37):

$$P=\left[\frac{n\rho^{\frac{\rho}{1-\rho}}\gamma\left(1-\rho\right)}{\left(1+\tau\right)^{\frac{\rho}{1-\rho}}\left(\gamma\left(1-\rho\right)-\rho\right)}\Phi\right]^{\frac{\rho-1}{\rho}}. \tag{2.37}$$

The demand for goods produced by taxpayers, $c^T(x)$, is defined as

$$c^T(x)=\frac{\left(w\bar{l}+\Pi+R\right)\left(\gamma\left(1-\rho\right)-\rho\right)\rho x^{\frac{1}{1-\rho}}}{n\left(1-\rho\right)\gamma\left(1+\tau\right)\Phi} \tag{2.38}$$

and the demand for goods produced by non-taxpayers, $c^{NT}(x)$ and $c_{\bar{\mu}}^{NT}(x)$, becomes

$$c^{NT}(x)=\frac{(1+\tau)^{\frac{\rho}{1-\rho}}\left(w\bar{l}+\Pi+R\right)\left(\gamma(1-\rho)-\rho\right)\rho x^{\frac{1}{1-\rho}}}{n(1-\rho)\gamma\Phi} \tag{2.39}$$

and

$$c_{\bar{\mu}}^{NT}(x)=\frac{(1+\tau)^{\frac{\rho}{1-\rho}}\left(w\bar{l}+\Pi+R\right)\left(\gamma(1-\rho)-\rho\right)\rho x^{\frac{1}{1-\rho}}}{\left(1+(1-\bar{\mu})\tau\right)^{\frac{1}{1-\rho}}n(1-\rho)\gamma\Phi}. \tag{2.40}$$

2.5 Definition of Equilibrium

The equilibrium for this economy is specified by a set of all the endogenous variables included in the model economy. That is, price functions $\hat{p}^{NT}(x)$, $\hat{p}_{\bar{\mu}}^{NT}(x)$, and $\hat{p}^{T}(x)$ for each productivity level x; a nominal wage rate $\hat{w}$; a consumption plan for consumers $\hat{c}^{NT}(x)$, $\hat{c}_{\bar{\mu}}^{NT}(x)$, and $\hat{c}^{T}(x)$; a production plan for producers $\left(\hat{y}^{NT}(x),\hat{l}^{NT}(x)\right)$, $\left(\hat{y}_{\bar{\mu}}^{NT}(x),\hat{l}_{\bar{\mu}}^{NT}(x)\right)$, and $\left(\hat{y}^{T}(x),\hat{l}^{T}(x)\right)$; aggregate profit flows $\hat{\Pi}$; aggregate transfers $\hat{R}$; a cutoff productivity level $\bar{x}_1^{NT}$ given by Eq. (2.23) such that firms drawing a productivity level x such as $x \geq \bar{x}_1^{NT}$ enter the market and with $x < \bar{x}_1^{NT}$ immediately exit the market; a cutoff tax evasion level $\bar{x}_2^{NT}$ given by Eq. (2.25) such that firms with $\bar{x}_1^{NT} \leq x \leq \bar{x}_2^{NT}$ produce $y^{NT}(x)$, evade taxes and are not caught; a cutoff tax evasion level $\bar{x}_1^{T}$ given by Eq. (2.28) such that firms with $\bar{x}_2^{NT} < x \leq \bar{x}_1^{T}$ evade taxes and produce a fixed level of $\bar{y}_L$; a cutoff tax evasion level $\bar{x}_2^{T}$ given by Eq. (2.30) such that firms with $\bar{x}_1^{T} < x \leq \bar{x}_2^{T}$ produce $y_{\bar{\mu}}^{NT}(x)$, evade taxes and are at risk to be caught with probability $1-\bar{\mu}$; a cutoff tax evasion level $\bar{x}$ given by Eq. (2.33) such that firms with $\bar{x}_2^{T} < x \leq \bar{x}$ evade taxes and produce a fixed level of $\bar{y}_H$ and are also at risk to be caught for tax evasion with probability $1-\bar{\mu}$; lastly, firms with a productivity level $x > \bar{x}$ produce $y^{T}(x)$ and pay taxes such that:

1. Given $\hat{p}^{NT}(x)$, $\hat{p}^{NT}_{\bar{\mu}}(x)$, $\hat{p}^{T}(x)$, $\hat{w}$, $\hat{\Pi}$, $\hat{R}$, the individual consumption plans $\hat{c}^{NT}(x)$, $\hat{c}^{NT}_{\bar{\mu}}(x)$, and $\hat{c}^{T}(x)$ solve the utility maximization problem of the representative consumer, that is, maximize Eqs.(2.4) subject to (2.5);

2. Given the direct demand function $\hat{c}^{T}(x)$ that comes from the consumer's problem (see Eq. (2.38)), the taxpayer firm chooses $\hat{p}^{T}(x)$ to solve Eq. (2.15);

3. Given the direct demand function $\hat{c}^{NT}(x)$ that comes from the consumer's problem (see Eq. (2.39)), the non-taxpayer firm chooses $\hat{p}^{NT}(x)$ to maximize Eqs. (2.18) subject to (2.19);

4. Given the direct demand function $\hat{c}^{NT}_{\bar{\mu}}(x)$ that comes from the consumer's problem (see Eq. (2.40)), the non-taxpayer firm chooses $\hat{p}^{NT}_{\bar{\mu}}(x)$ to maximize Eqs. (2.18) subject to (2.19);

5. The markets for goods clear and are given by Eqs. (2.41) to (2.44):

$$\hat{y}^{i}(x) = \hat{c}^{i}(x),\ i = NT, T; \tag{2.41}$$

$$\hat{y}^{NT}_{\bar{\mu}}(x) = \hat{c}^{NT}_{\bar{\mu}}(x); \tag{2.42}$$

$$\bar{y}_L = \bar{c}_L; \tag{2.43}$$

$$\bar{y}_H = \bar{c}_H; \tag{2.44}$$

6. The factor markets clear and are given by Eq. (2.45):

$$n\int_{\bar{x}_1^{NT}}^{\bar{x}_2^{NT}} \hat{l}^{NT}\left(y^{NT}(x)\right)dF(x) + n\int_{\bar{x}_2^{NT}}^{\bar{x}_1^{T}} \hat{l}^{NT}\left(\bar{y}_L\right)dF(x) + n\int_{\bar{x}_1^{T}}^{\bar{x}_2^{T}} \hat{l}^{NT}_{\bar{\mu}}\left(y^{NT}_{\bar{\mu}}(x)\right)dF(x) +$$

$$n\int_{\bar{x}_2^{T}}^{\bar{x}} \hat{l}^{NT}_{\bar{\mu}}\left(\bar{y}_H\right)dF(x) + n\int_{\bar{x}}^{\infty} \hat{l}^{T}\left(y^{T}(x)\right)dF(x) = \bar{l}; \tag{2.45}$$

7. The number of variety available for consumption is the number of varieties produced given by Eq. (2.46):

$$n\int_{\bar{x}_1^{NT}}^{\bar{x}_2^{NT}} dF(x) + n\int_{\bar{x}_2^{NT}}^{\bar{x}_1^{T}} dF(x) + n\int_{\bar{x}_1^{T}}^{\bar{x}_2^{T}} dF(x) + n\int_{\bar{x}_2^{T}}^{\bar{x}} dF(x) + n\int_{\bar{x}}^{\infty} dF(x) = \bar{n}. \tag{2.46}$$

2.6 Calibration and Numerical Results

In this section I examine the quantitative properties of the model. I consider the sensitivity of the results to alternative parameterizations of the model economy. I explore how the equilibrium properties of the model change with variations in the probability of detection, tax rate, and penalty cost. The model predictions determine what parameter or a combination of the parameters has a larger impact on tax compliance behavior.

I choose Russia as a country of analysis to calibrate my model for the year 1998. Here I will explain the methods I used for my parameterization.

I assume a Pareto distribution for firm productivity,

$$f(x) = \begin{cases} \gamma x^{-\gamma-1} \text{ for } x \geq 1 \\ 0 \quad \text{otherwise} \end{cases},$$

where $k = 1$ is the minimum value for productivity $(x \geq k)$; $\gamma > 0$ is a shape parameter that determines the skewness of the Pareto distribution. In addition to being tractable, this distribution provides a reasonable approximation of observed variation in firm productivity. It is difficult to calibrate the shape parameter γ since there is no direct data on firms' productivity levels. In addition, we cannot recover the true distribution of productivity because of non-observability of output (typically we have data on sales). I use 1998 data on employment size across Russian firms using the dataset "Fundamental information across Russian firms" provided by ZAO "Russian Investment Association". I follow Gabaix et al. (2003) and Luttmer (2007) to construct the size distribution of firms. Let S denote the actual employment size of the firm. I rank firms from largest (rank 1) to smallest (rank n) so that $S_{(1)} \geq \ldots \geq S_{(n)}$. I then draw a graph, known as Zipf's plot: on the y-axis, the log of the rank (the largest firm has log rank $\ln 1$, the smallest firm has long rank $\ln n$ take the log of employment level[5]. I find that the size distribution of firms in Russia is different from the U.S. firm distribution. As in Luttmer (2007), the U.S. size

[5] The given number of firms n in 1998 is equal to 5537. Hence, $\ln 5537 = 8.6$.

distribution of firms almost perfectly fits a straight line with the slope -1.06. The Russian micro-level dataset misses a number of small firms. They constitute sectors like wholesale and retail trade, health care and social work, education, art and culture, financial services, and public administration. The possible explanation is that such small firms do not submit their budget reports to avoid being seen and caught for tax evasion. This proves the fact that in Russia small firms evade more than large firms. Figure 2.1 shows the size distribution of firms generated by the firm- level data for 1998. To find a Pareto shape parameter, economists run a regression of the log of number of firms on the log of employment to obtain the tail index of the Pareto distribution, assuming the data is generated by a Pareto distribution. The regression takes a linear form

$$\mathbf{y} = \mathbf{X}\mathbf{b} + \mathbf{e},$$

where $\mathbf{X}$ is an n-by-2 matrix, where the first column is an identity column vector, and the second column is a column of the log of employment; $\mathbf{y}$ is an n-by-1 vector of the log of number of firms; the vector $\mathbf{b}$ is a 2-by-1 matrix of regression coefficients; and the vector $\mathbf{e}$ is an n-by-1 vector of the residuals. Due to the fact that there must be a number of missing firms, I assume that γ is equal to 2.5. I have chosen it to be greater than 2 to make sure that γ has a finite mean.

The wage rate is normalized to one. To calibrate the values for the entry cost f, I use the study by Djankov et al. (2002) who collected data on the start-up costs across firms in 85 countries in 1999. The data covers all procedures – the number of procedures, official time, and official cost – that a start-up firm must bear before it can operate legally. For example, in Russia an entrepreneur must complete 20 procedures which take at least 57 days and must pay $449 US dollars to open a business. This is equivalent to 11,076.80 rubles[6] in 1999 and approximately equals to 5,467.14 in 1998 rubles[7]. Barkhatova (2000) estimates that in 1997 in Russia the costs of formal registration of a company was approximately 4,824 rubles. This includes state registration of a small company which requires paying the following fees: (i) 50% of the initial capital, the minimum amount of

[6] The average ruble/US dollar exchange rate in 1999 is 24.67.
[7] The formula for turning ruble figures from 1999 into 1998's rubles is the following:

$$\text{Amount in 1998 rubles} = \text{Amount in 1999 rubles} \times \frac{\text{Price level in 1998}}{\text{Price level in 1999}} = 11,076.80 \times \frac{6,099}{12,357} = 5,467.14.$$

I use http://ier.org.ua/tables/Table%202.1%20Q.pdf for CPI index.

which is 100 times the official minimum wage, that is $83.5 \times 100 = 8,350$ rubles, so at the very beginning it is necessary to pay half of this amount, that is, $4,175$ rubles; (ii) registration fees to the municipal budget are 150 rubles; (iii) registration fees to the State Statistics Committee are 144 rubles; and (iv) registration fees for specimen signatures (four signatures) are 355 rubles; thus state registration of a private company costs 4,824 rubles. This amount in 1998 dollars is equal to 5,262.14 rubles which is roughly five times the average nominal monthly wage[8]. Both estimates are very close. Here I assume that a fixed entry cost $f = 5$ which is five times the average nominal wage rate.

The penalty cost for tax evasion in Russia in 1998 was a fine of 200-500 times the minimum wage. The minimum wage in Russia in 1998 was 83.49 rubles. The penalty cost of tax evasion is between 16,698 and 41,745. In calibration I am going to use the average of these two numbers (29,221.5) which is 350 times the minimum wage or 28 times the average nominal wage. Hence, the penalty cost for tax evasion ζ is equal to 28.

To calibrate the effective tax rate τ, I analyze statistical balance reports of 5,537 firms in 1998. Table 2.2 gives a sample balance sheet of an industrial firm submitted on January 1, 1998. I have included only the data relevant for my analysis. The balance sheet contains gross and net wages, social security contributions and information on number of employees. All earned wages are subject to one-percent mandatory pension fund deductions. Using all the above information, I can calculate the tax rate in each firm given by Eq. (2.47):

$$tax = \frac{(1-0.01)NZP^{declared} - RZP}{NZP^{declared}} \times 100\%, \qquad (2.47)$$

where $NZP^{declared}$ is the nominal declared wage payments before deductions, and RZP is the nominal wage payment after deductions.

To find the effective tax rate, that is, the tax rate paid by the firms that fulfill their tax obligations, I use two selection mechanisms. One mechanism is based on the difference between average monthly wages prescribed by Goskomstat across industries, w^I, and wages paid by the firm, w^F. If the difference between these two, $w^I - w^F$, is less than or equal to zero, then the firm fully pays its tax duties, otherwise, I consider it as a tax

[8] The average nominal monthly wage in 1998 was 1,051.50 rubles.

cheater. Another method is based on the assumption that all firms truly pay their pension fund contribution duties (since they care about their retirement) which constitute 28 percent of employee's wages. Knowing the data for pension fund contributions, we can find the true value for gross wages as follows

$$NZP^{true} = \frac{PFC}{0.28}.$$

The true value of payroll tax payments can now be found using Eq. (2.48)

$$(1-0.01)NZP^{true} - RZP. \tag{2.48}$$

The size of tax evasion is then

$$(1-0.01)\left(NZP^{true} - NZP^{declared}\right) \tag{2.49}$$

Equation (2.49) allows me to distinguish between tax payers and tax evaders. To calculate the effective tax rate, I select only tax payers and take the average payroll tax. I find that the efficient tax rate $\tau = 14.62\%$.

In 1998 the total number of firms in Russia, denoted by n is assumed to be 2.9 million firms (see Table 2.3) and total active employment l is 58.437 million people. The data limitations seem to be sufficiently challenging obstacle to my analysis, and, in particular, to empirically specify the parameter ρ, $\overline{y}_L$ and $\overline{y}_H$. The parameter ρ governs the elasticity of substitution $\sigma = 1/(1-\rho)$, willingness of buyers to substitute goods produced by taxpayers (legal goods) and goods made by tax evaders (informal goods) of the same variety. The parameter ρ is chosen to be 0.7 so that the condition $\gamma > \sigma - 1$ holds. The elasticity of substitution is now equal to 3.33. Note that when $\sigma > 1$, as in our case, a decrease in ρ means an increase in the informal sector. In our case, due to the higher elasticity of substitution, individuals are more willing to substitute the formal goods for the informal good. The parameters $\overline{y}_L$ and $\overline{y}_H$ indicate the boundary levels of output – low and high, respectively - so that if the firm's production level falls in-between these two values it gets detected with probability $1-\overline{\mu}$. I have not attempted to produce an econometric estimate of the parameters $\overline{y}_L$ and $\overline{y}_H$, I simply let $\overline{y}_L = 600$ and $\overline{y}_H = 1,200$

so that the informal share of output is close to 44 percent[9]. I summarize the calibrated parameter values in Table 2.4.

Next I do a sensitivity analysis, beginning with the baseline model. Assuming $\overline{\mu} = 1$, we have a production function of the form given by Figs. 2.2 and 2.3. The figures show that the small firms keep evading taxes until they start to produce at $\overline{y}_H$, that is, 1,200 units (which corresponds to the firm's labor efficiency level of 6.72 or nearly 183 workers employed). To avoid paying all taxes, they keep producing at this pre-determined level until they reach the efficiency of 9.76. Since the labor productivity grows, such firms no longer need to maintain the same number of workers, and as Figure 2.3 shows, the employment level declines to 129 workers employed. The fact that firms need fewer employees means they can make lower payroll tax payments. Moreover, to avoid being seen, they charge the same price as low-efficiency firms. Figures 2.4 and 2.5 illustrate this situation. A higher price and lower labor costs generate higher profit (see Fig. 2.6). Since I let tax rate be zero, production function, price and profit functions of the tax evaders with zero probability of detection and tax evaders with a $1-\overline{\mu}$ -chance of getting caught coincide.

Figure 2.7 illustrates the structure of firms for the case of zero probability of detection. Tax evading firms constitute 15.54% of all the firms in the economy, tax paying firms 0.34%, and the remaining 84.12 % decide to exit the market due to high entry costs. Given the parameters of the model, the size of the informal economy is nearly 44.04%, close to empirical estimates of the size of the shadow economy in Russia.

Next, I vary the probability of tax detection to see how it affects firms' compliance decision. Assume that the firms face a two-percent chance of getting caught. Figure 2.8 shows that the small firms with efficiency levels between 2.09 and 5.46 produce less than the low threshold level $\overline{y}_L$ and are not monitored. According to Fig. 2.9, this corresponds to the firms with more than 16 but less than 114 workers. Once the firms reach a productivity level of 5.46 or higher that allows them to produce more than $\overline{y}_L$, they decide to fix their production at $\overline{y}_L$ and pretend as if they are low-efficiency firms. A rise

[9] The IMF analysis shows that the size of shadow economy for Russia in 1998 is 44 percent.

in efficiency level from 5.46 until 5.86 allows such firms to reduce the number of employees from 114 until 107 and not to pay any taxes. The firms with productivity greater than 5.86 (or 133 workers) decide that they would be better off by producing more than $\bar{y}_L$ and take a small risk of being caught. They continue to do so until the total number of workers gets equal to 183 workers, and they are able to produce no less than $\bar{y}_H$. Once firms are able to produce more than $\bar{y}_H$, they face a similar dilemma: either to fix their production level at $\bar{y}_H$ and have a small chance of being caught for tax evasion, or continue to produce more than $\bar{y}_H$ and pay all taxes. Figure 2.9 shows that a small fraction of such firms benefit more by fixing their output at $\bar{y}_H$ while others with employment greater than 272 workers decide to fully comply with their tax obligations and produce more than 2,595 hundreds units of output. Figures 2.10 and 2.11 show the price function as a function of efficiency and production level, respectively. Due to the fact that firms with $\bar{y}_L$ and $\bar{y}_H$ fix their prices (as shown in Figs. 2.10 and 2.11), they are able to significantly increase their profit illustrated in Fig. 2.12.

The structure of firms is slightly different now. We observe a small increase in tax evading firms from 15.54% until 15.56% of which 14.70% evade taxes with no risk and 0.86% face a two-percent chance of getting caught. The number of tax paying firms stays the same and is equal to 0.34%, and the remaining 84.10 % decide to exit the market due to the given parameters. Given the parameters of the model, the size of the informal economy gets down and becomes 43.89% which is lower by 0.34%.

Finally, I vary penalty costs and tax rates together with the probability of tax detection to see their impact on the size of informal sector, tax revenues, and calibrated income. Certainly, zero taxes make real income higher but the government needs money to finance purchases, so this would not be possible (see Table 2.5). The higher the probability of detection gets, the harder it becomes for the firms to avoid being seen. If so, the tax revenue increases and the informal sector goes down (see Table 2.6). An increase in penalty costs provides an additional constraint for firms and makes tax evasion less desirable. As a result, the informal sector declines and tax revenues increase.

2.7 Conclusion

In this paper I considered tax evasion decision of firms. To acknowledge the heterogeneity of plants, I introduce Ricardian differences in technological efficiency across producers. To explain the coexistence, even within the same industry, of tax evaders and taxpayers, I specify the governmental policies. Based on the tax policies, I identify efficiency levels of the firms that decide to go underground and assume that mostly inefficient firms choose to operate in the shadow economy. I build a monopolistic competition model of tax evasion in which inefficient firms decide to evade taxes whereas efficient firms make all tax payments.

I calibrate the model to Russia in 1998 and find that to fight tax evasion the government needs to increase monitoring and/or set up higher penalty costs. Assuming that the total number of firms fixed, this reduces the number of tax evaders and reduces the size of shadow economy. A large increase in the probability of detection and/or increase in penalty costs also lead to an increase in tax revenues.

The model can be further extended. Based on the size distribution of firms, it will be interesting to determine the optimal tax rate and find out what causes some small firms truly report their employment level and others decide not to do so.

Chapter 3

Applied General Equilibrium Analysis of Taxation and International Trade in Russia

3.1 Introduction

After proclaiming independence in late 1991, Russia embarked on the difficult transition from central planning to a market economy. The transition involved an abrupt contraction in trade with former socialist economies as well as a considerable amount of reduction in the offered subsidies to various sectors. The sudden change in the economic course triggered Russia to take the step of accessing other world economies: the markets of the World Trade Organization (WTO) member countries. But differences over some critical issues like Russia's tariff structure make uncertain the timetable for Russia's access to the WTO.

In this chapter, I present a static applied general equilibrium (GE) tax model to evaluate the impact in Russia of the 2000-2001 tariff reform on relative prices, domestic production, trade volume, government revenue, and welfare. To perform a series of numerical experiments, I have used the information contained in the social accounting matrix (SAM).

The SAM which contains 20 industrial sectors – a much higher degree of disaggregation than any such matrix in the existing literature on the Russian economy – is based on an input-output (IO) table of 2003, the most recent year available. In addition, I carry out the sensitivity analysis with respect to different values for Armington elasticities of import substitution across sectors. As far as of import substitution between sectors, the econometric estimates are taken from Alekseev (2003). The computational model reported here simultaneously accommodates several taxes: indirect taxes on production and consumption goods, income tax, tariffs and export taxes. Incorporating various tax instruments helps me to appraise the effect of one tax change only on other taxes and provides a fresh insight into trade policy discussions. In my model there present both a government deficit and trade surplus. The government deficit is modeled as a purchase of government bonds while the trade surplus as the capital outflows. The consumers consider bonds and foreign investment as perfect substitutes for physical capital as savings instruments.

My analysis shows that tariff elimination associated with the possible access to the WTO would cause significant changes in trade flows between Russia and the rest of the world, the overall increase of imports into Russia in all sectors, and the diversification of Russia's industries. However, at the same time we can observe a drop in domestic production in almost all sectors and a drop in exports of natural gas and crude oil. These being the most important industries, even a slight drop in such sectors could lead to huge economic losses. By adopting the tariff elimination policy, the government would lose a significant part of its budget which, in my model, could be compensated by imposing high export taxes on foreigners. Sensitivity analysis shows that my results are robust to the changes in Armington elasticities. Overall, a free trade agreement between Russia and the rest of the world is not an optimal form of economic integration for Russia.

Chapter 3 is related to a wider series of applied GE modeling popularized in the 1960s and 1970s. Using the Walrasian general-equilibrium structure, these models were aimed at evaluating policy options such as the distortionary effects of taxes, tariffs and other policies, and to assess who gains and loses by the effects of such policy changes.

The relatively recent empirical studies on applied GE models are used to quantify possible outcomes of the European Union (EU) enlargement, the effects of the North American Free Trade Agreement (NAFTA), and the access to the World Trade Organization (WTO) by countries in Central and Eastern Europe and Latin America. These studies include the works of Kehoe and Serra-Puche (1983), Kehoe, Manresa, Noyola, Polo, and Sancho (1988), Rutherford and Paltsev (1999), Lejour, Mooji, and Nahuis (2001), Alekseev, Tourdyeva, and Yudaeva (2003), Kehoe (2003), Jensen, Rutherford, and Tarr (2004), and Cho and Diaz (2006). For instance, Kehoe et al. (1988) analyze the economic effect of the 1986 tax reform in Spain after it entered the then European Economic Community (EEC). Cho and Diaz (2006) give the quantitative estimates of the potential gains and losses of two trade liberalization episodes within Ecuador and Slovenia. Rutherford and Paltsev (1999), the case of Russia, analyze the marginal excess burden of various tax instruments in Russia based on an unbalanced 1995 Russian input-output table with 9 sectors. The authors recreate an Arrow-Debreu (1954) general equilibrium model, elaborated on to Arrow and Hahn (1971) in MPSGE (Mathematical Programming System for General Equilibrium Analysis) format, a programming language elaborated in the 1980s to solve computable general equilibrium models. Using the Global Trade Analysis Project (GTAP) data base for the year of 1997, Lejour, Mooji, and Nahuis (2001) focus primarily on the impact of the EU enlargement on potential candidates and on the existing members of the EU. They model Russia as an integrated member of the Former Soviet Union (FSU), not as a separate region. Therefore, the results must be interpreted carefully. Unlike this work, Alekseev, Tourdyeva, and Yudaeva (2003) managed to model Russia as an autonomous region and concentrate on the cost/benefit analysis of the abolishment of the trade barriers between the EU and the Central and Eastern European Countries (CEECs) for the Russian economy. To conduct simulation experiments, the authors use a comparative static (without modeling any explicit time periods) multi-regional computable general equilibrium model with 15 production sectors for the year 2000. They found that a change in tariffs associated with access to the WTO does not make a significant change to the Russian economic environment. However, the creation of the Common European Economic Space (CEES) – a free trade area between Russia and the enlarged Europe – would make the Russian economy diversify its domestic production: a drop in oil, gas and nonferrous metallurgy production which accounts in nominal terms for almost €64 million (Euros) (Alekseev et al. (2003), p.9) and an increase in the sectors such as ferrous metallurgy, food processing industry, agriculture, and construction.

The rest of this chapter is as follows: Section 3.2 describes the data base to illustrate how a general equilibrium model can be adapted for policy evaluation work; Section 3.3 discusses the essential elements of the applied general equilibrium model with taxes placing emphasis on the choice of parameter values and functional forms; and Section 3.4 analyzes the numerical results of two policy scenarios suggested by the trade liberalization reform. I close this chapter with the lessons learned from the results and what could be the direction for future research. The appendix contains graphs and tables.

3.2 Data

To provide a comprehensive and detailed description of the transactions in the Russian economy, I use a social accounting matrix, familiarly known as SAM. The use of SAM can be traced back to Stone (1947), the primary architect of the United Nations System of National Accounts (the UN SNA), the System of Social and Demographic Statistics (SSDS), and Quesnay's (1759) *Tableau Economique*. Despite the fact that SAM presents only a static image of the economy and clearly cannot reveal much information on dynamics, it serves as a good statistical basis of the country's economic structure. For example, if policy makers are concerned about the distribution of income to different households based upon a change in government expenditures, then the SAM can be constructed to create multiple household sectors based on various income levels (Miayazawa, 1976). Likewise, the distribution of profits from industry sectors can be accomplished by creating proprietorship and corporate firm categories (Fannin, 2000). The SAMs are able to directly address similar types of questions. Therefore, it is not surprising why researchers and policy makers have demonstrated an increasing interest in applications of SAMs to policy analyses over the past two decades (Pyatt and Round, 1985 and Kehoe, 1996).

The SAM framework embodies the information normally included in national income accounts and the Leontief (1941) input-output model of production. The data sources used to construct the SAM for Russia are the official 2003 input-output table provided by Goskomstat (the Federal State Statistics in Russia), national account statistics, and data collected from the World Bank and the International Trade Administration of the U.S. Department of Commerce.

The SAM matrix presented here has a much higher degree of sectoral disaggregation and precision than any such matrix in the existing literature on the Russian economy. Given the key importance of oil and gas production in Russia, there is a particular interest in evaluating how oil-related industries might respond to potential trade liberalization scenarios. Thus, unlike any previous works on trade liberalization reforms in Russia, I will consider the crude oil extraction, oil manufacturing, and natural gas industries separately. In total, the matrix contains 20 industries and 20 products. A list of these sectors can be found in Table 3.1.

The paper does not attempt to explain how to construct the SAM; however, a brief explanation of how the data is organized might be useful. The SAM, by definition, is a series of accounts put in the matrix form. The entries in the matrix represent receipts when read across rows and expenditures when read down columns. Thus the entry in row i, column j, represents receipts by account i from account j or, alternatively, expenditures by account j that are paid to account i. Since the principles of double-entry bookkeeping apply, incomings into one account must balance with the outgoings from another account.

Table 3.2 illustrates in schematic form the structure of the SAM for Russia. The rows and columns of the matrix are grouped into blocks: production goods sectors, consumption goods sectors, factors of production, institutions, the capital account, and the foreign sector. Let us take a close look at some of them.

I start with the production account (1) labeled here as “production goods sectors.” It represents production sector outputs that are used as intermediate inputs, at producers’ prices, for production good industries, consumption good industries and for the final consumption by household, government, investment/savings, and the rest of the world.

The SAM factor account (3) is split into two factors of production: labor and capital. Together they are used in the production process and receive income from the process. Since the original 2003 use IO table does not explicitly provide the data on labor and capital income, I first calculate the labor and capital share using the data on components of gross value added at producers’ prices from the table. Gross value added corresponds to the income items of compensation to employees, gross profit (or gross operating surplus), gross mixed income, other taxes on production, other subsidies on production, and indirectly measured financial intermediation. Knowing the fractions of capital and labor income and total value added, I am then able to find a good approximation of labor earnings and return on capital.

In terms of institutional detail, the SAM includes one account each for households, government, investment/savings, and the rest of the world. Households supply labor and capital. In here, households and non-commercial organizations serving households are combined under one institutional category. Another type of institution is government which plays an important role in the production process. It purchases exogenously fixed amounts of some production goods and services. It also provides subsidies, levies taxes on consumer income, ad valorem taxes on production, ad valorem taxes on consumption, and taxes on imported and exported goods. Government spending and government revenue are normally not equal and must be balanced by borrowing or lending. In Russia’s case, government expenditure exceeds its income resulting in a deficit that is balanced by issuing bonds. Russia’s account for the rest of the world keeps track of goods and services imports between Russian institutions and the rest of the world. Here I assume that imports and exports of goods and services are not distinguished by trading partner. Since the value of exported goods by far exceeds the number of imported products, there is external surplus. The resulting trade surplus is handled in the similar way as the government deficit: households buy the investment good from the rest of the world.

Due to the lack of data on tariffs, the information on domestic tariff rates is based on the MFN tariff rates for Russia from the World Bank. The data on foreign tariffs is calculated based on the Global Trade Analysis Project 6 (GTAP 6) data base. The data on export tax rates is taken from the report on Russia prepared by the U.S. Department of Commerce, Bureau of Industry and Security, and is assumed to be equal to 20% across all production sectors. [10]

The elasticities of substitution for exports and imports are not calibrated but taken from the existing literature. I assume that the import elasticity of substitution, $\rho_{m,j}$, for all $j \in G_p$, is uniform across sectors and equals to 0.8 in case 1. In addition, based on Alekseev (2003), I consider case 2 in which I allow the import elasticity of substitution to vary across sectors. The values of the import elasticity of substitution are summarized in Table 3.3. Higher values of elasticities imply more responsive behavior of economic agents when tariffs change. That is, in the case of higher import elasticity of substitution between domestic and imported goods, consumers tend to switch more easily between such goods. Regarding the exports elasticity of substitution, $\rho_{x,j}$, its value is assumed to be fixed across all sectors with the values of 0.9 in cases 1 and 2. Regarding the exports elasticity of substitution, $\rho_{x,j}$, its value is assumed to be fixed across all sectors with the value of 0.9 in cases 1 and 2.

3.3 Model

I construct a static applied general equilibrium (GE) model in the Shoven-Whalley tradition. This model is a representation of a small open economy with several agents:

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10 https://www.bis.doc.gov/DefenseIndustrialBasePrograms/OSIES/ExportMarketGuides/european/russia.pdf

households, producers of production and consumption goods, a domestic government, and the rest of the world. All consumers in the model are identical.

3.3.1 Households

I assume that there is a representative household with the linear log utility function:

$$\sum_{j \in G_c} \theta_j^c \log c_j + \theta_{inv}^c \log\left(c_{inv}^d + c_{inv}^f + c_b\right),$$

where c_j is the consumption of good $j \in G_c$, where G_c is the set of consumption goods; c_{inv}^d is the private domestic investment; c_{inv}^f is the capital outflow compensating for the Russian trade

surplus; and c_b is the purchase of government bonds. Together, the purchases of the domestic and foreign investment account for consumer savings. Consumers can also save by purchasing government bonds. The government bonds are regarded by consumers as perfect substitutes for physical investment (Kehoe et al., 1994).

I assume that the consumer solves a utility-maximization problem of the form

$$\max \sum_{j \in G_c} \theta_j^c \log c_j + \theta_{inv}^c \log\left(c_{inv}^d + c_{inv}^f + c_b\right)$$

subject to

$$\sum_{j \in G_c} p_j^c c_j + p_{inv}\left(c_{inv}^d + c_{inv}^f + c_b\right) = \left(1 - \tau_d\right)\left(w\bar{l} + r\bar{k}\right)$$

$$c_j, c_{inv}^d, c_{inv}^f \geq 0$$

In the budget constraint p_j^c is the price of consumption good j, $j = 1,...,20$, p_{inv} is the price of the investment good. Consumers have after-tax income from selling the services of their labor and capital. Here w and r are the factor prices, $\bar{l}$ and $\bar{k}$ are the aggregate endowments of labor and capital, and τ_d is the direct tax rate. The parameters $\left\{\theta_j^c\right\}_{j \in G_c}, \theta_{inv}^c$ satisfy the properties $\left\{\theta_j^c\right\}_{j \in G_c}, \theta_{inv}^c \geq 0$ and $\sum_{j \in G_c} \theta_j^c + \theta_{inv}^c = 1$.

3.3.2 Production Goods Producers

I assume that there are three major types of producers: a production good producer, a consumption good producer, and an investment good producer. In addition, the production good producers are distinguished by the type of production good they produce. Here there are final good producers and domestic good producers. I describe each one in detail.

3.3.2.1 Final Goods Producers

In this model the final good producer combines both domestically produced and imported goods of the same product category to produce an aggregate final good. In simple small-country models where goods are distinguished by country of origin we usually deal with the Armington (1969) specification. This specification allows a different degree of substitution between domestic and imported goods, the fluctuation of domestic goods prices with even the smallest country having some market power (Kehoe et al., 1994). The general production function of the final good is

$$y_j = \gamma_j \left[\delta_j \left(y_j^d \right)^{\rho_{m,j}} + \left(1-\delta_j\right)\left(y_j^f \right)^{\rho_{m,j}} \right]^{\frac{1}{\rho_{m,j}}},$$

where $\sigma_{m,j} = \dfrac{1}{1-\rho_{m,j}}$ is the constant elasticity of substitution between domestic and imported goods that varies across goods. Here, y_j is the output of the final production good $j \in G_p$, where G_p is the set of production goods; y_j^d is the domestic production of good $j \in G_p$; and y_j^f is imports of good $j \in G_p$.

Cost minimization further implies that y_j^d and y_j^f solve

$$\min \; p_j^d y_j^d + \left(1+\tau_j\right) e p_j^f y_j^f$$

subject to

$$\gamma_j \left[\delta_j \left(y_j^d \right)^{\rho_{m,j}} + \left(1-\delta_j\right)\left(y_j^f \right)^{\rho_{m,j}} \right]^{\frac{1}{\rho_{m,j}}} \geq y_j$$

Here, p_j^d is the price of domestic component of final good j, p_j^f is the price of imported component of final good j, τ_j is the tariff rate that Russia imposes on imports from the rest of the world of good j, and e is the bilateral real exchange rate; the share parameter δ_j is and the factor productivity γ_j are parameters to be calibrated. The data on tariffs is given in Table 3.4. Note that when $\rho_{m,j}$ approaches zero, the production function takes Cobb-Douglas functional form

$$y_j = \gamma_j \left[\left(y_j^d \right)^{\delta_j} \left(y_j^f \right)^{1-\delta_j} \right].$$

The zero profit of the final good sector implies

$$p_j y_j - p_j^d y_j^d - e\left(1+\tau_j\right) p_j^f y_j^f = 0$$

where p_j is the producer price of the final good in sector j.

3.3.2.2 Domestic Goods Producers

Suppose that n is the total number of industries. Here, n is equal to 20. I assume that the production of the domestic component of the final good is governed by a constant-returns production function of the form

$$y_j^d = \min\left\{ \frac{x_{1,j}^d}{a_{1,j}^d}, \ldots, \frac{x_{i,j}^d}{a_{i,j}^d}, \ldots, \frac{x_{n,j}^d}{a_{n,j}^d}, \beta_j k_j^{\alpha_j} l_j^{1-\alpha_j} \right\}.$$

Here, $x_{i,j}^d$ is the intermediate input of good i used in the production of good j, $i = 1,\ldots,n$, $j = 1,\ldots,n$; $a_{i,j}^d$ is unit intermediate input requirement in the production of good j; k_j and l_j are the capital and labor inputs; and $a_{i,j}^d, \alpha_j, \beta_j$ are parameters to be calibrated.

I assume that domestic good producers minimize costs and earn zero after-tax profits. Cost minimization further implies that k_j and l_j solve

$$\min wl_j + rk_j$$

subject to

$$\beta_j k_j^{\alpha_j} l_j^{1-\alpha_j} = y_j^d .$$

Again, w is the wage rate and r is the capital rental rate.

The zero after-tax profit condition implies

$$\left(1-t_j^p\right)p_j^d y_j^d - \sum_{i\in G_p} p_i x_{ij} - wl_j - rk_j = 0,$$

where t_j^p is the indirect tax rate on sales of good j in inter-industry transactions.

Since I assume that producers do not waste inputs, the production function for good j can be written as

$$y_j^d = \frac{x_{1,j}^d}{a_{1,j}^d} = \ldots = \frac{x_{i,j}^d}{a_{i,j}^d} = \ldots = \frac{x_{n,j}^d}{a_{n,j}^d} = \beta_j k_j^{\alpha_j} l_j^{1-\alpha_j}\ .$$

Hereafter, the zero after-tax profit condition becomes as follows

$$\left(1-t_j^p\right)p_j^d y_j^d - \sum_{i\in G_p} p_i a_{i,j}^d y_j - wl_j - rk_j = 0.$$

3.3.3 Consumption Goods Producers

In this model, I assume that the consumption goods purchased by households are different from the production goods traded between industries. The consumption goods a consumer purchases have a very high component of services embodied in them. For example, raspberries purchased by consumers are different from raspberries bought by a firm to produce raspberry jam. Therefore, here, I differentiate between consumption goods and production goods.

The consumption goods firms combine final production goods in fixed proportion under the production function specified below:

$$y_j^c = \min\left\{\frac{x_{1,j}^c}{a_{1,j}^c},\ldots,\frac{x_{i,j}^c}{a_{i,j}^c},\ldots,\frac{x_{n,j}^c}{a_{n,j}^c}\right\}.$$

Here, y_j^c is the output of the consumption good $j \in G_c$, where G_c is the set of consumption goods; $x_{i,j}^c$ is the intermediate input of final production good i used in the production of good $j \in G_c$; $a_{i,j}^c$ is the amount of final good i required to produce one unit of good $j \in G_c$.

Again, I assume that producers of consumption goods never waste inputs, and the production function for consumption good j can then be written as

$$y_j^c = \frac{x_{1,j}^c}{a_{1,j}^c} = \ldots = \frac{x_{i,j}^c}{a_{i,j}^c} = \ldots = \frac{x_{n,j}^c}{a_{n,j}^c}.$$

I construct the model so that I make producers of consumption goods pay taxes to the government and not consumers. The after-tax zero profit condition implies

$$\left(1 - t_j^c\right) p_j^c y_j^c - \sum_{i \in G_c} p_i a_{i,j}^c y_j^c = 0,$$

where t_j^c is the commodity sales tax on good j; $a_{i,j}^c$ is to be calibrated.

3.3.4 Investment Good Producers

To account for the savings observed in the data, I include purchases of the investment good in the utility function. In a dynamic setting, agents buy the investment good in one period and augment their capital stock in the next. Unlike dynamic models, static models treat investment as another final demand for goods like consumption goods.

The production function for the investment good is

$$y_{inv}^d = \min\left\{ \frac{x_{1,inv}^d}{a_{1,inv}^d}, \ldots, \frac{x_{i,inv}^d}{a_{i,inv}^d}, \ldots, \frac{x_{n,inv}^d}{a_{n,inv}^d} \right\}.$$

I consider the investment good to be produced by selling a combination of other production goods rather than by any process that involves labor and capital.

Again, I assume that investment good producers minimize costs so that

$$y_{inv}^d = \frac{x_{1,inv}^d}{a_{1,inv}^d} = \ldots = \frac{x_{i,inv}^d}{a_{i,inv}^d} = \ldots = \frac{x_{n,inv}^d}{a_{n,inv}^d}$$

and earn zero profits. This assumption implies that $x_{1,inv}^d, \ldots, x_{n,inv}^d$ solve

$$p_{inv} y_{inv}^d - \sum_{i \in G_p} p_i a_{i,inv}^d y_{inv}^d = 0.$$

3.3.5 Government

In models that primarily focus on trade and public finance issues, the government is treated as an independent decision maker. Like consumers, the government derives utility from purchasing goods and services and receives income from taxes: ad valorem taxes on production and consumption, consumer income, taxes on exported goods and tariffs. An interesting feature of this model is that the government spends more than it receives in revenue. Government deficits are usually modeled as sales of bonds by the government to the other consumers (Kehoe et al., 1994). These bonds constitute a part of household savings. In the computation of general equilibrium such a deficit on current expenditures appears in the government's budget constraint as a positive endowment of capital tomorrow (Kehoe and Serra-Puche, 1983). The problem of the government can be written as follows:

$$\max \sum_{i \in G_p} \theta_i^g \log c_i^g$$

subject to

$$\sum_{i \in G_p} p_i c_i^g = \tau_d \left(w\bar{l} + r\bar{k} \right) + \sum_{j \in G_p} t_j^p p_j^d y_j^d + \sum_{j \in G_c} t_j^c p_j^c y_j^c + \sum_{j \in G_p} \tau_j e p_j^f y_j^f + p_{inv} w_b + \sum_{j \in G_p} \tau_j^e p_j x_j^f ,$$

where p_{inv} and w_b are the price and the endowment of capital tomorrow in the hands of government.

3.3.6 Foreign Sector

A common way to model foreign trade is to introduce a foreign sector, known here as the rest of the world. A representative consumer purchases imported goods $x_j^f, j \in G_p$ and consumes a locally produced good x_f^f. The representative consumer in the rest of the world chooses a consumption plan $\left\{ x_j^f \right\}_{j \in G_p}, x_f^f$ to solve

$$\max \left[\sum_{j \in G_p} \theta_j^f \left(x_j^f \right)^{\rho_x} + \theta_f^f \left(x_f^f \right)^{\rho_x} - 1 \right] / \rho_x$$

subject to

$$\sum_{j \in G_p} \left(1 + \tau_j^f \right) p_j \left(1 + \tau_j^e \right) x_j^f + e x_f^f = e I_f ,$$

where τ_j^f is the tariff rate on imported goods $j, j \in G_p$, in the foreign country (see Table 3.5) ; τ_j^e is the tariff rate on exported goods $j, j \in G_p$, imposed on foreigners, e is the bilateral real exchange rate; I_f is the income of the household in the foreign country; and

$\sigma_x = \dfrac{1}{1-\rho_x}$ is the constant export elasticity of substitution between domestic and imported goods that is common across goods. The income of the rest of the world is determined exogenously. Nevertheless, it implicitly contains the corresponding capital inflow from Russia to account for trade surplus.

3.4 Definition of Equilibrium

All the elements described above are linked by the concept of equilibrium. Equilibrium for this economy is specified by a set of all the endogenous variables included in the model economy. That is, prices for final production goods $\left\{\hat{p}_j\right\}_{j\in G_p}$, prices for domestic production goods $\left\{\hat{p}_j^d\right\}_{j\in G_p}$, prices for consumption goods $\left\{\hat{p}_j^c\right\}_{j\in G_c}$, price for the private domestic investment good $\hat{p}_{inv}$, a wage rate $\hat{w}$, a capital rental rate $\hat{r}$, foreign prices $\left\{\hat{p}_j^f\right\}_{j\in G_p}$, a bilateral real exchange rate $\hat{e}$, a consumption plan for domestic consumers $\left(\left\{\hat{c}_j\right\}_{j\in G_c}, \hat{c}_{inv}\right)$, a consumption plan for government $\left\{\hat{c}_i^g\right\}_{i\in G_p}$, a consumption plan for the rest of the world $\left(\left\{\hat{x}_j^f\right\}_{j\in G_p}, \hat{x}_f^f\right)$, a production plan for the final good producers $\left\{\left(\hat{y}_j\right), \hat{y}_j^d, \hat{y}_j^f\right\}_{j\in G_p}$, a production plan for the domestic good producers $\left\{\left(\hat{y}_j^d, \hat{x}_{1,j}^d, ..., \hat{x}_{i,j}^d, ..., \hat{x}_{n,j}^d, \hat{k}_j, \hat{l}_j\right)\right\}_{j\in G_p}$, a production plan for the consumption good producer $\left\{\left(\hat{y}_j^c, \hat{x}_{1,j}^c, ..., \hat{x}_{i,j}^c, ..., \hat{x}_{n,j}^c\right)\right\}_{j\in G_c}$, a production plan for the private domestic investment good producer $\left\{\hat{y}_{inv}^d, \hat{x}_{1,inv}^d, ..., \hat{x}_{i,inv}^d, ..., \hat{x}_{n,inv}^d\right\}$. Given tax rates and tariffs, a set of prices and production and consumption plans must satisfy the following properties:

1. The consumption plan $\left(\left\{\hat{c}_j\right\}_{j\in G_c}, \hat{c}_{inv}\right)$ solves the domestic consumer's utility-maximization problem;

2. The consumption plan $\left\{\left(\hat{x}_j^f\right)_{j\in G_p}, \hat{x}_f^f\right\}$ solves the problem of the representative household in the rest of the world;

3. The production plan $\left\{\left(\hat{y}_j\right), \hat{y}_j^d, \hat{y}_j^f\right\}_{j\in G_p}$ solves the problem of the final good producer. It satisfies the costs minimization subject to the feasibility constraints and zero after-tax profit condition;

4. The production plan $\left\{\left(\hat{y}_j^d, \hat{x}_{1,j}^d, ..., \hat{x}_{i,j}^d, ..., \hat{x}_{n,j}^d, \hat{k}_j, \hat{l}_j\right)\right\}_{j\in G_p}$ solves the problem of the domestic good producer;

5. The production plan $\left\{\left(\hat{y}_j^c, \hat{x}_{1,j}^c, ..., \hat{x}_{i,j}^c, ..., \hat{x}_{n,j}^c\right)\right\}_{j\in G_c}$ solves the problem of the consumption good producer;

6. The production plan $\left\{\hat{y}_{inv}^d, \hat{x}_{1,inv}^d, ..., \hat{x}_{i,inv}^d, ..., \hat{x}_{n,inv}^d\right\}$ solves the problem of the investment good producer;

7. Supply equals demand in the market for each produced good:

$$\hat{y}_i = \sum_{j\in G_p} \hat{x}_{i,j}^d + \sum_{j\in G_c} \hat{x}_{i,j}^c + \hat{x}_{i,inv}^d + \hat{c}_i^g + \hat{x}_i^f \quad \text{for all } i \in G_p,$$

$$\hat{y}_j^c = \hat{c}_j \quad \text{for all } j \in G_c,$$

$$\hat{c}_b = \hat{w}_b^g,$$

$$\hat{y}_{inv} = \hat{c}_{inv} - \hat{c}_b - \hat{c}_{inv}^f,$$

where $\hat{c}_{inv}$ is the private savings, $\hat{c}_b$ is sales of government bond holdings, and $\hat{c}_{inv}^f$ is net capital outflow;

8. Supply equals demand in each factor market:

$$\bar{l} = \sum_{j\in G_p} \hat{l}_j,$$

$$\bar{k} = \sum_{j\in G_p} \hat{k}_j;$$

9. The trade balance condition holds

$$\hat{e}\left(\sum_{j\in G_p} \hat{p}_j^f \hat{y}_j^f + \hat{p}_{inv}^f \hat{c}_{inv}^f\right) = \sum_{j\in G_p} \hat{p}_j \hat{x}_j^f.$$

3.5 Numerical Experiments

In this section I analyze the potential effects of two trade liberalization reforms on Russia: one of partial and one of complete tariff elimination. I gradually lower tariff rates imposed on foreigners across all sectors, and then calculate the new equilibrium. In addition, I perform a sensitivity analysis by allowing the import elasticities of substitution to vary across sectors. In general, the values of all of the endogenous variables change. Taking the benchmark simulation as a primer reference, I report the implications on prices, domestic production, trade, and welfare together with the economic intuition behind obtained results.

Since trade liberalization is a gradual process, I start by considering a partial liberalization scenario whereby Russia and the rest of the world bilaterally lower all import tariffs by 50%. Table 3.6 summarizes the results on Russia's domestic prices and domestic production for various values of Armington specification used in the final good production in the benchmark and partial liberalization.

The percentage change in total domestic production of each sector for case 1 with uniform values of substitutability $\rho_{m,j}$ and $\rho_{x,j}$ for all j is given in Figure 3.1.

The Armington specification is an essential factor which determines production and trade patterns. In case of uniform substitution between domestic and foreign goods, total domestic production in Russia will decrease in almost all sectors except oil extraction industry, transportation and other services but still those changes are very small. The largest decrease in domestic production of tradable goods will take place in light industry and food industry which are the most highly protective industries followed by machinery, chemicals, and other manufacturing industries.

Figure 3.2 and Table 3.7 show the numerical values of the percentage change in Russian domestic good production for all cases given export and import elasticities of substitution. In both cases with imperfect substitutability we almost always observe a decline in domestic production. The highest decline occurs in light and food industry. As the results suggest, Russia mainly suffers on the domestic production side. The main reason is that, after trade liberalization, Russian domestic production faces higher competition from goods produced in the rest of the world and therefore domestic production falls.

On average, the size of final good production goes up slightly by 0.14% in case 1 and decreases by 0.21% as in case 2.

Table 3.8 gives the results on the volume of exports and imports with the rest of the world. On average, the exports of all primary and manufactured goods with the rest of the world increased by 12.09% and 8.61% in cases 1 and 2, respectively. The largest increase occurs in the food and light industries. As for imports, they increase by 22.45% and 18.85% in the same cases.

The results of this model coincide with the facts suggested in the paper by Aussilloux and Pajot (2001), the research by Alekseev et al. (2003), and others. For instance, Alekseev et al. (2003) argue that, in the case of the European Union (EU) enlargement, producer prices within the EU will be lower than the prices on the same goods produced in Russia leading to higher levels of Russian imports and lower levels of exports. As given in Table 3.8, Russian exports of natural gas fall in the range between 21.87% and 23.88% and crude oil fall in the range between 9.69% and 15.60%. Since Russian exports are mostly concentrated in oil and gas, even a slight drop in these sectors will result in a huge loss in nominal values. Russian imports would increase in all sectors of the economy.

Finally, I examine the impact of partial liberalization on the national welfare. The functional forms of the welfare function vary greatly depending on a statement of objectives it is intended to express. Here, since agents are assumed identical, what matters is how much benefit each good with its own assigned weight generates to the aggregate consumption. Therefore, the consumer welfare measured by the consumer real income index is given by $\prod_{j=1}^{20}\left(c_j\right)^{\theta_j} \times \left(c_{inv}^d + c_{inv}^f + c_b\right)^{\theta_{inv}}$, where j varies over the consumption goods $j = 1,...,20$ and the investment good. The government welfare measured by the government real income index is given by $\prod_{i=1}^{20}\left(c_i^g\right)^{\theta_i^g}$, where i varies over the production goods $i = 1,...,20$. The social welfare measured by the social real income index is defined as $\prod_{j=1}^{20}\mathbb{C}_j^{\Theta_j}$, where $\mathbb{C}_j = c_j + (c_{inv}^d + c_{inv}^f + c_b) + c_j^g$ and

$\Theta_j = \frac{c_j + \left(c_{inv}^d + c_{inv}^f + c_b\right) + c_j^g}{\sum_{j=1}^{20} c_j + \left(c_{inv}^d + c_{inv}^f + c_b\right) + \sum_{j=1}^{20} c_j^g}$. Additionally, these functional forms yield the convex welfare indifference curves. In both cases of imperfect substitutability, due to some increase in imports and collection of export taxes as well as a purchase of bonds, the government welfare improves but not by much as shown in Table 3.9. The overall social welfare fell by approximately 2%.

Next, I examine the impact of a hypothetical case of complete liberalization reform in Russia. This implies that Russia and the rest of the world agree to eliminate import tariffs across all sectors, holding other trade barriers fixed. As in the example above, I consider both cases of import elasticity.

Table 3.10 summarizes the results on Russia's domestic prices and domestic good production for various values of Armington specification used in the final good production in the benchmark and complete liberalization. As in the case of partial liberalization, the highest decline occurs in light and food industry which accounts for 42.56 % and 23.14%, respectively, in case 1, and for 87.84% and 22.40%, respectively, in case 2. On average, the size of final good production increased slightly by 1.05% and by 1.07 % as in cases 1 and 2, respectively.

Table 3.11 shows the estimates on the volume of exports and imports with the rest of the world. On average, the exports of all primary and manufactured goods with the rest of the world increased by 33.94% and 29.77% in cases 1 and 2, respectively. As for imports, they increase by 56.66% and 49.16% in the same cases, respectively. Note that the number of imported goods from the rest of the world becomes higher than the number of exported commodities (see Figure 3.3). It appears that a significant change occurs in the food and non-ferrous metallurgy industries. Under the import elasticity of 0.8, the percentage increase in the food industry is equal to 126.31% and in non-ferrous metallurgy 99.07%. Once we allow the import elasticity to vary across sectors, say, in food industry it is 0.789 and in non-ferrous metallurgy it is 0.806, the percentage increase in food industry is equal to 121.82% and in non-ferrous metallurgy 108.35%. The fact that Russia will import more non-ferrous metals from abroad was also supported in the literature.

Finally, I examine the impact of complete liberalization on the national welfare. The government tariff revenue loss is reflected in the decline in government welfare, which fell by 0.13% and 0.29% in cases 1 and 2, respectively (see Table 3.12). The consumer welfare improves compared to partial liberalization example, except in the case when $\rho_{m,j} = 0.8$ across all sectors.

3.6 Trade Effect on Government Budget

One method used to measure the degree of protectionism within an economy is the average tariff rate. Since tariffs generally reduce imports of foreign products, the higher the tariff, the greater the protection afforded to the country's import-competing industries. At one time, tariffs were perhaps the most commonly applied trade policy. Many countries used tariffs as a primary source of funds for their government budgets. However, as trade liberalization advanced in the second half of the twentieth century, many other types of non-tariff barriers became more prominent. Generally speaking, average tariff rates are less than 20% in most countries, although they are often quite a bit higher in the case of agricultural commodities. In the most developed countries, average tariffs are less than 10%, and often less than 5%. On average, less developed countries maintain higher tariff barriers, but, for many countries that have recently joined the WTO, tariffs have recently been reduced substantially to gain entry.

In this section I analyze how the two trade liberalization scenarios affect government revenues in Russia. In my model the government receives money from imposing taxes on production, consumption, income, imports and exports, and by issuing government bonds.

Table 3.13 contains the details in percentage terms on Russia’s government revenue structure. It reveals that an abolishment of tariffs will lower tariff revenues up to zero but, on the other hand, will both increase trade flows and in this way increase government revenue received from taxing exports. Tax revenues from production goods reflect the fact that less and less industries will be subsidized by the government. In my model, government bond holdings that account for government deficit in the benchmark do not change as much. If we consider revenues from direct taxes and consumption, we can see that the fall in tariff revenues will result in the decline in revenues from taxes on consumption and direct taxes as shown in cases 1 and 2.

To compensate for the loss in government revenue in the case of complete liberalization, I perform two comparative static experiments that tend to show compensatory effective tax rates on consumption (VAT) and exports. In the first, I let the VAT vary endogenously so that it covers the loss in government revenue and the budget constraint holds with equality. In the second, I allow the taxes on exported goods to adjust so that the government budget is balanced. The analysis finds that, given uniform values of elasticity of substitution, the effective VAT rate jumps from 7.84% up to 7.95% whereas the effective export tax rate goes up from 17.84% to 19.08%. Under the assumption of various elasticity of substitution, the effective VAT rate rises from 7.84% to 8.04% whereas the effective export tax rate increases from 17.84% to 19.09%. Comparing these two policy instruments, I find that the taxes on export tend to increase the social welfare more than the VAT.

3.7 Conclusion

This paper is an attempt to analyze the potential effects of two possible trade liberalization scenarios: partial and complete elimination of import tariffs in Russia and the rest of the world. Using an applied general equilibrium model as the most appropriate tool for quantitative evaluation, I provide numerical estimates on changes in production, consumption, trade flows, and welfare after the creation of a free trade area between Russia and the rest of the world.

The analysis has shown that a free trade agreement between Russia and the rest of the world is not an optimal form of economic integration for Russia. Despite the fact that tariff elimination generates significant changes in the volumes of Russian imports and exports, and by doing so has a positive impact on Russian economy, the Russian consumers do not gain in terms of lower domestic pricing on imports. As a result, consumers' welfare as well as social welfare both show sizable losses. Russian domestic production shrinks as more and more imported goods become available. The tariff diminution causes a reduction in government budget and therefore subsidies to domestic producers. To compensate the budget loss, in my model the government can choose to impose either higher taxes on consumption or higher export taxes on foreigners. Both policies increase government welfare but decrease consumer and social welfare which in the long run might lead to bigger economic loses.

It is important to note that this paper is not designed to provide a dynamic aspect of trade liberalization process. It also does not cover the welfare effects on high-income versus low-income households as well as trade effects between distinguished trading partners. Incorporating these issues might be an interesting idea for future research.

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Appendices

Appendices to Chapter 2

Appendix A: Tables

Table 2. 1 Percentage of sales reported to tax authorities, by size of firm

Firms \ Percentage of sales	100	90-99	80-89	70-79	60-69	50-59	<50
Small	25.83	10.30	9.78	8.05	5.38	8.17	11.48
Medium	36.05	11.68	9.30	6.72	5.06	6.52	7.94
Large	41.43	10.70	7.53	5.45	4.10	5.19	7.79
Total	32.96	10.93	9.13	7.01	4.99	6.92	9.33

Total = average for all firms in the WBES sample.
Source: Batra *et al.* (2003)

Table 2. 2 Statistical report of an individual firm (in thousands), 01.01.1998

Description	Symbol	Data
Gross Wages	*NZP*	6,476,430
Net Wages	*RZP*	4,738,270
Social Security Contributions:		
Social Security Fund	*SSFC*	333,062
Pension Fund	*PFC*	2,241,161
Employment Fund	*EFC*	93,946
Medical Insurance Fund	*MIFC*	240,726
Number of Employees	*L*	95

Source: ZAO "Russian investment corporation"

Table 2. 3 Number of small businesses and total number of firms in Russia (in thousands)

Firms \ Years	1992	1993	1994	1995	1996	1997	1998
Small Businesses	560.0	865.0	896.9	877.3	841.7	861.1	868.0
Total Number of Firms	609.0	1,244.9	1,946.3	2,249.5	2,504.5	2,727.1	2,901.2
% of Small Firms to Total Number of Firms	**92.0**	**69.5**	**46.1**	**39.0**	**33.8**	**31.6**	**29.9**

Source: Goskomstat, 1998: 342; Statisticheskoe Obozrenie, 1999, no.3: 19; Goskomstat, 1996:226; Goskomstat, 1999: 274, 281; Alimova and Ermilova, 2000

Table 2. 4 Calibrated parameters for Russia, 1998

Symbol	Description	Data	Target
n	Total number of firms	2,901,200	Goskomstat, 1998
l	Total labor supply	58,437,000	Goskomstat, 1998
f	Entry fixed costs	5	Djankov et al. (2002)
ρ	Curvature parameter	0.7	The elasticity of substitution is 3.33
γ	Pareto distribution parameter	2.5	A tail index of the size distribution of firms
μ	Probability of not being detected	1	
ζ	Penalty costs	28	28 times the nominal wage
τ	Payroll tax rate	0.1462	The effective tax rates across tax payers
$\overline{y}_L$	Low level of output	600	To match the shadow economy
$\overline{y}_H$	High level of output	1,200	To match the shadow economy
w	Wage rate	1	Normalization

Table 2. 5 Tax effect on calibrated income in Russia, 1998 (in millions)

Probability of detection / Tax rates, %	$1-\overline{\mu}=0$		$1-\overline{\mu}=0.02$	
	Real Income	**Change, %**	**Real Income**	**Change, %**
$\tau=0.00$	**91,966**	0.00	**94,206**	0.00
$\tau=11.70$	89,616	-2.55	92,858	-1.43
$\tau=13.16$	89,266	-2.94	92,634	-1.67
$\tau=14.62$	88,906	-3.33	92,398	-1.91
$\tau=16.08$	88,535	-3.73	92,153	-2.18
$\tau=17.54$	88,154	-4.15	91,899	-2.45

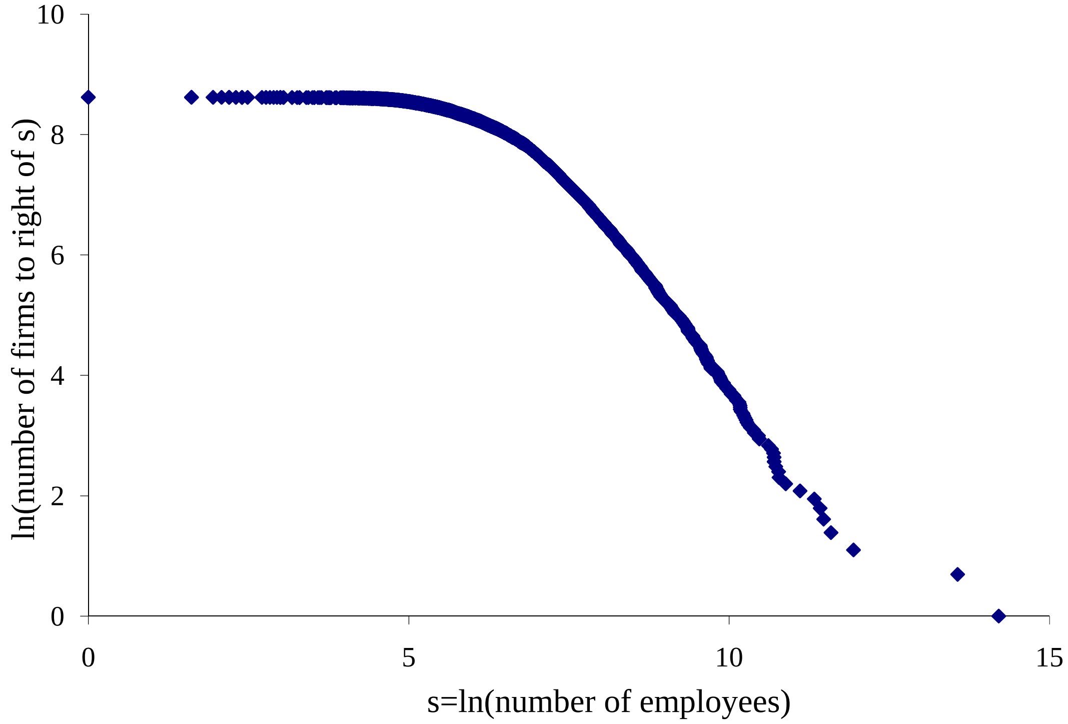
Source: Own calculations

Table 2. 6 Comparative statics on shadow economy and tax revenues for the case of $1-\overline{\mu}=0.2$

Parameters / Change wrt to baseline (in %)	$\tau=0.15$	$\tau=0.12$	$\tau=0.18$	$\zeta=28$	$\zeta=22.4$	$\zeta=33.6$
Shadow Economy	-0.90	-1.83	20.96	-0.90	-0.72	-1.05
Tax Revenues	4.14	-13.96	-0.09	4.14	3.86	4.39

Source: Own calculations

Appendix B: Figures



Source: Own calculations

Figure 2. 1 Size distribution of Russian firms in 1998.

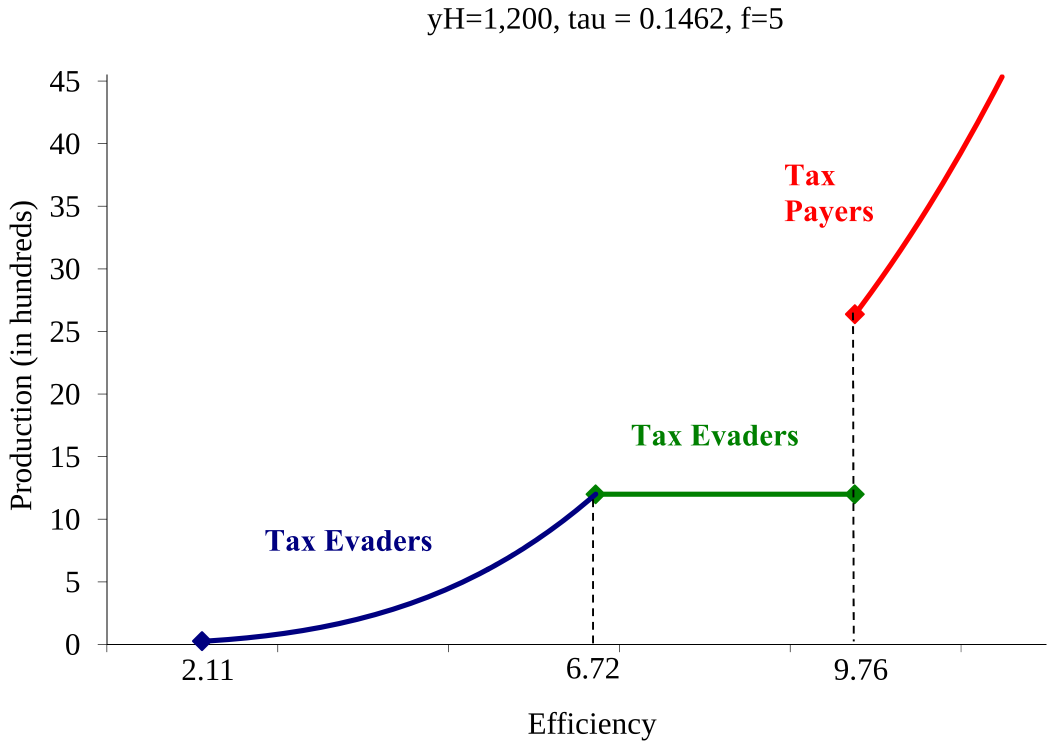


Figure 2. 2 Production as a function of efficiency for the case of $1-\overline{\mu}=0$.

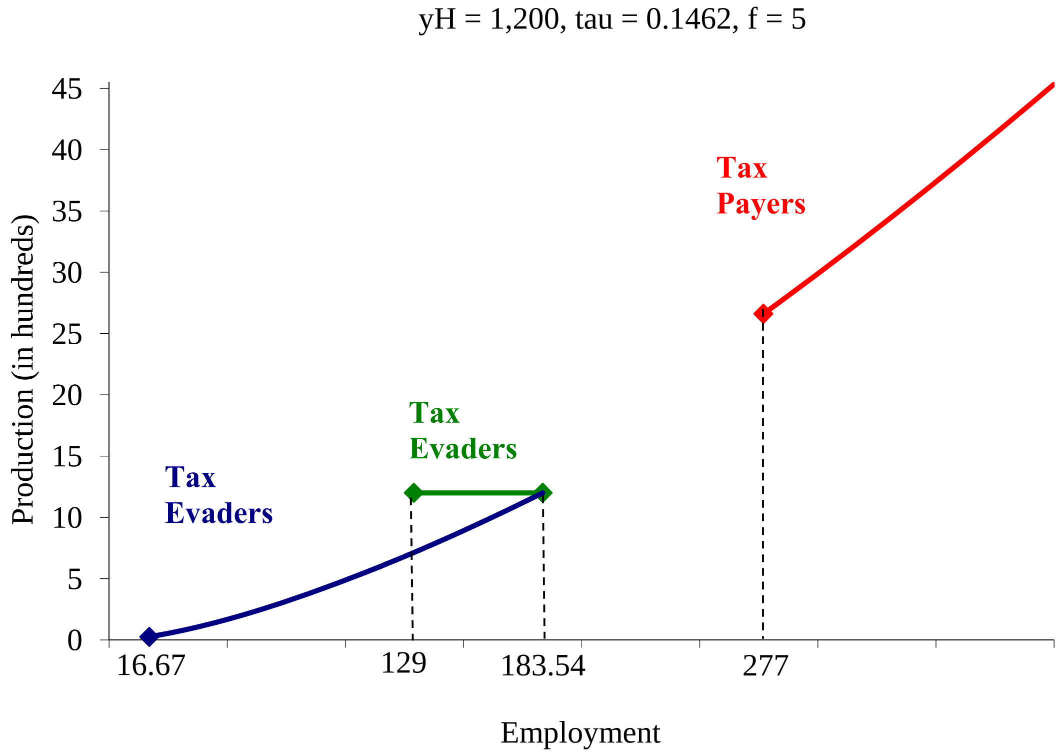


Figure 2. 3 Production as a function of employment for the case of $1-\overline{\mu}=0$.

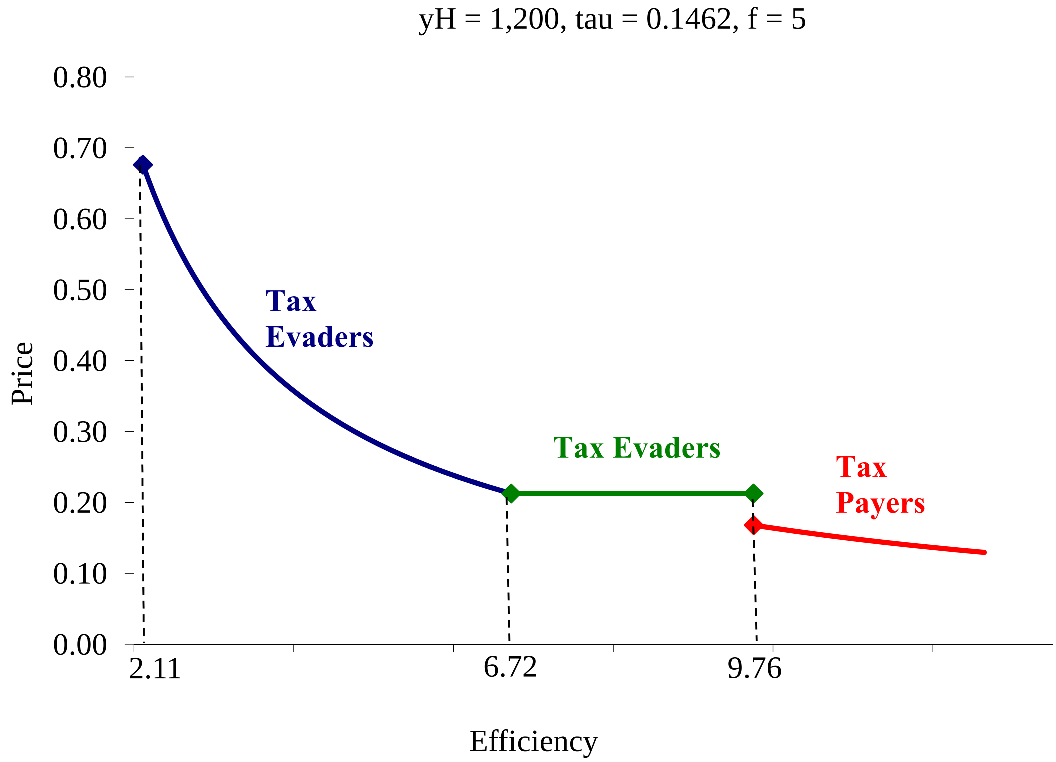


Figure 2. 4 Price as a function of efficiency for the case of $1-\overline{\mu}=0$.

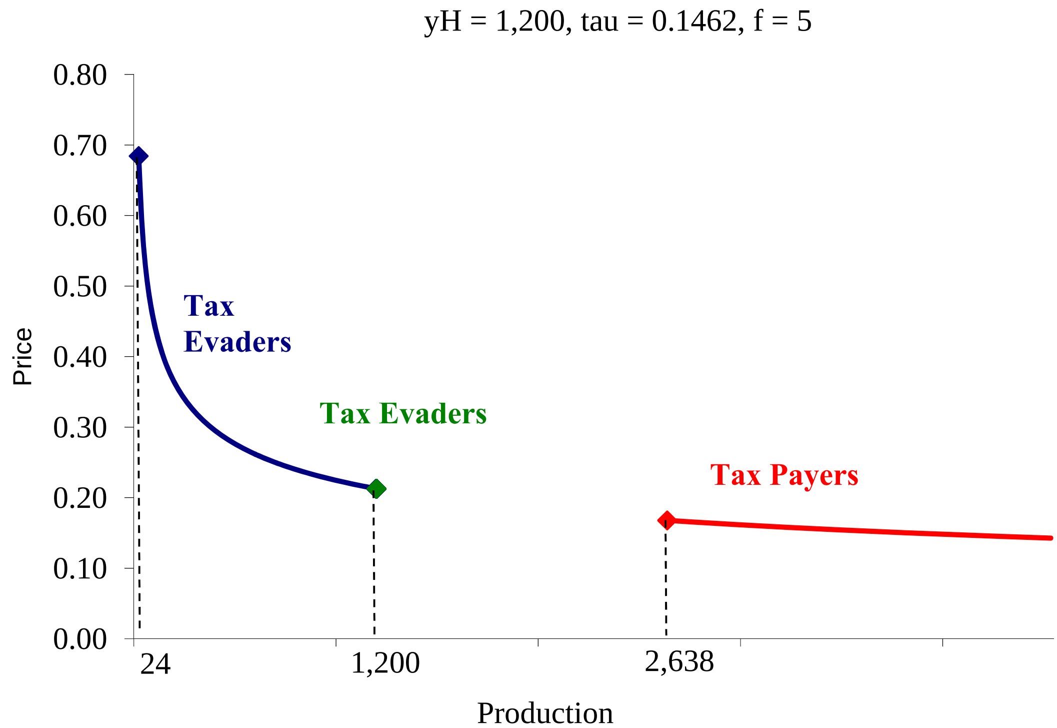


Figure 2. 5 Price as a function of production for the case of $1-\overline{\mu}=0$.

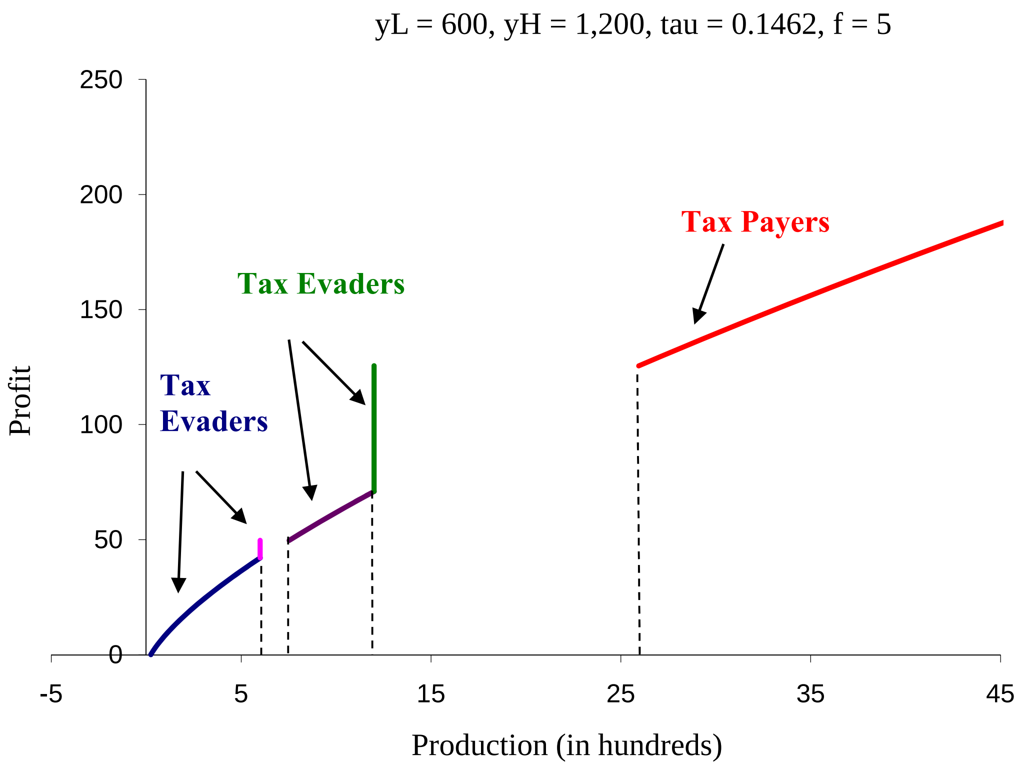


Figure 2. 6 Profit as a function of production for the case of $1-\overline{\mu}=0$.

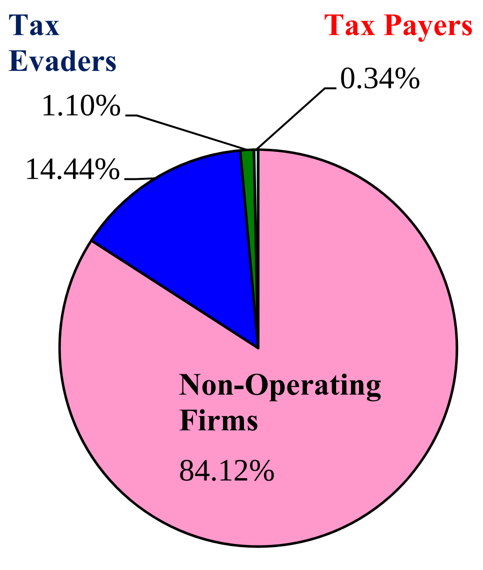


Figure 2. 7 The structure of firms for the case of $1-\overline{\mu}=0$.

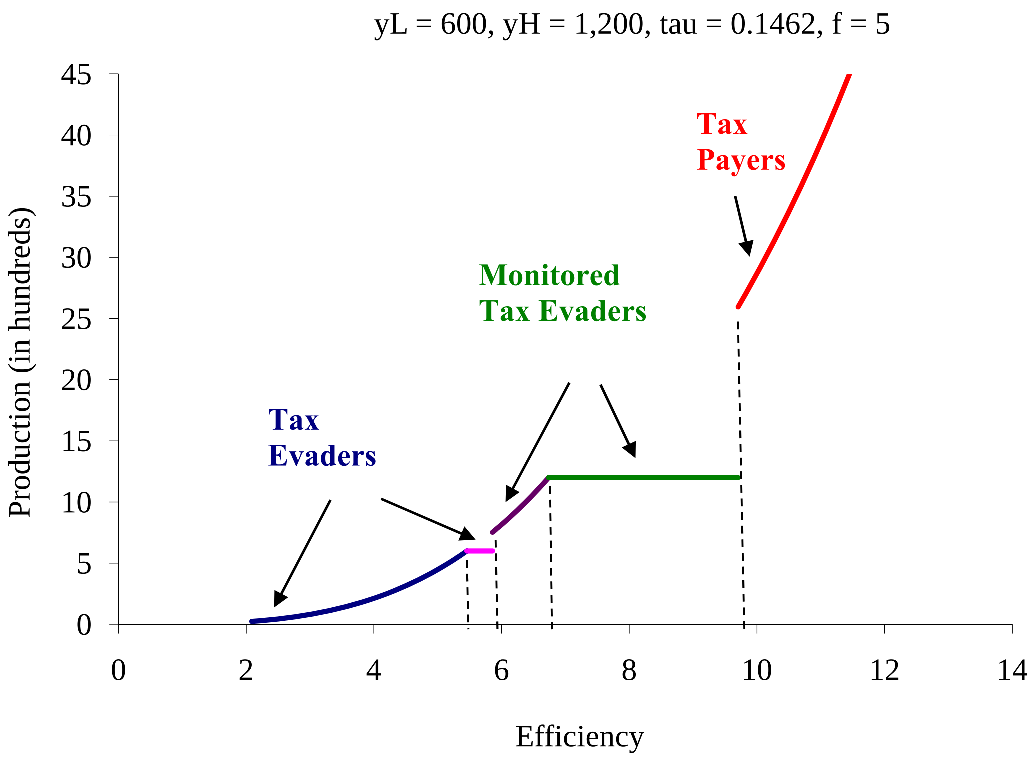


Figure 2. 8 Production as a function of efficiency for the case of $1-\overline{\mu}=0.02$.

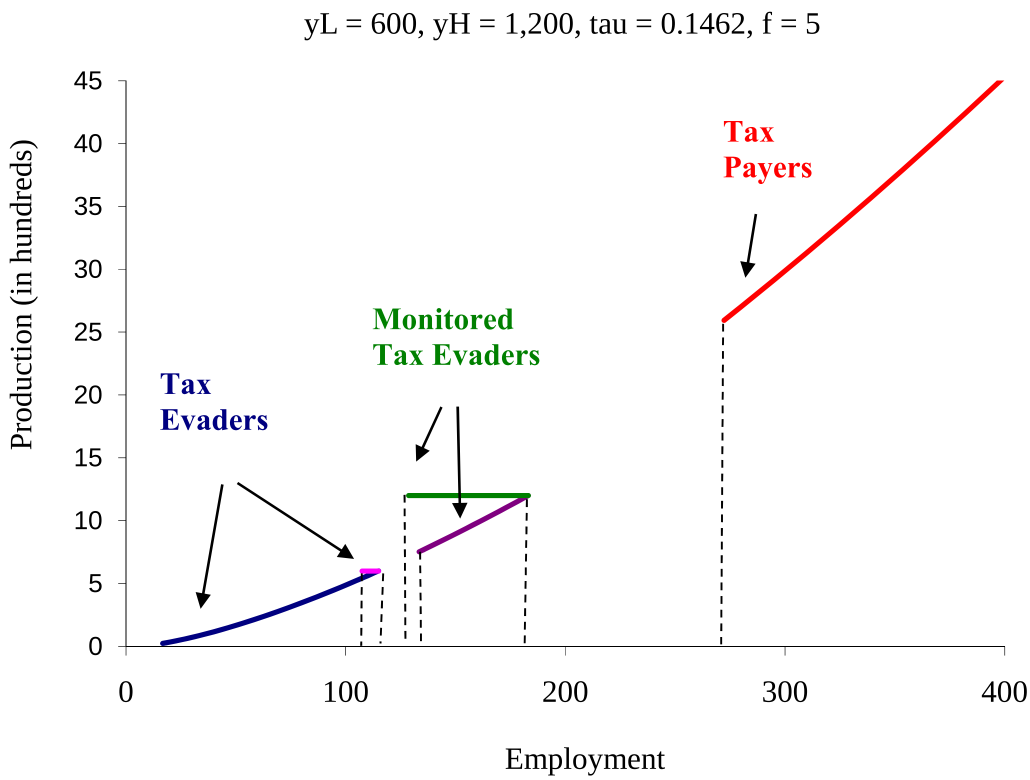


Figure 2. 9 Production as a function of employment for the case of $1-\overline{\mu}=0.02$.

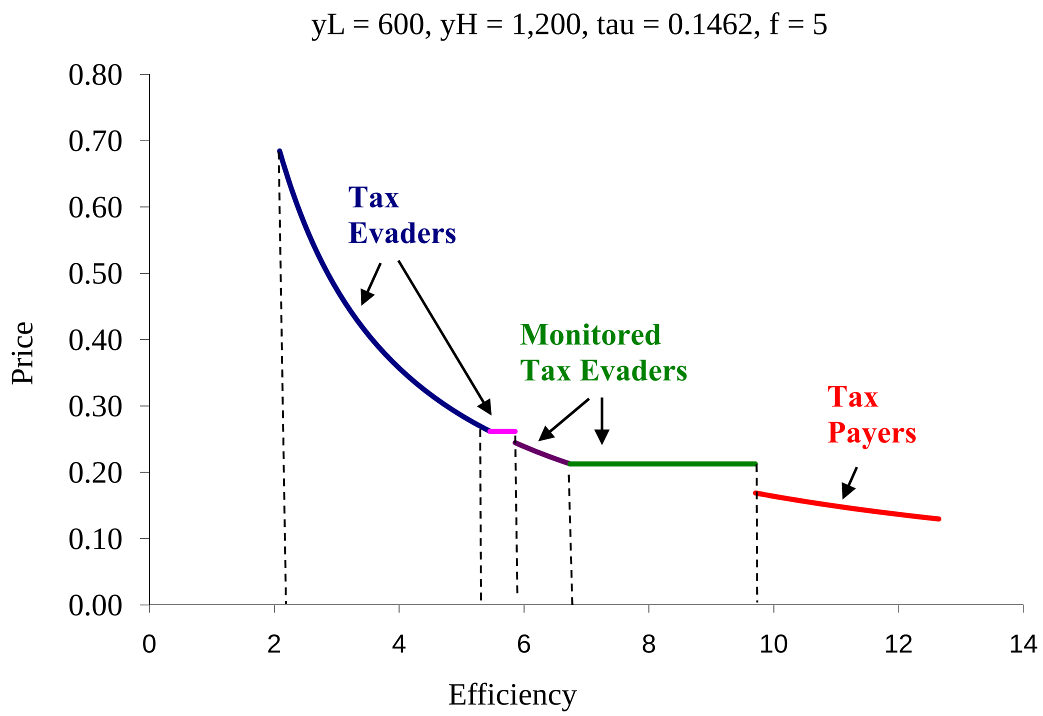


Figure 2. 10 Price as a function of efficiency for the case of $1-\overline{\mu}=0.02$.

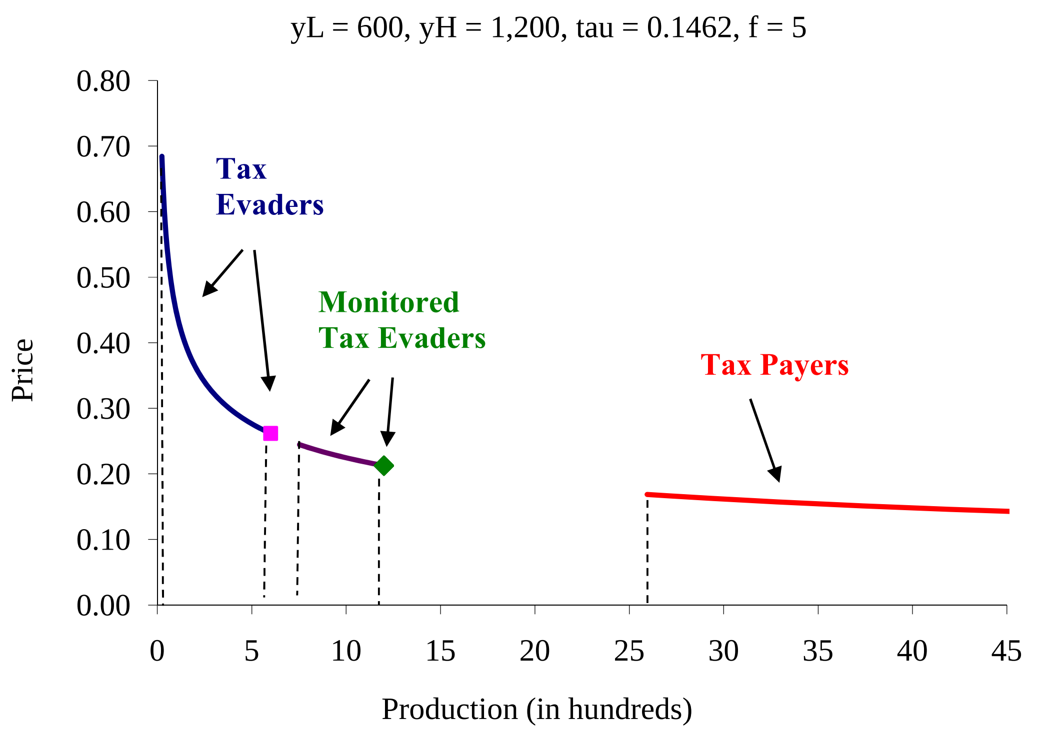


Figure 2. 11 Price as a function of production for the case of $1-\overline{\mu}=0.02$.

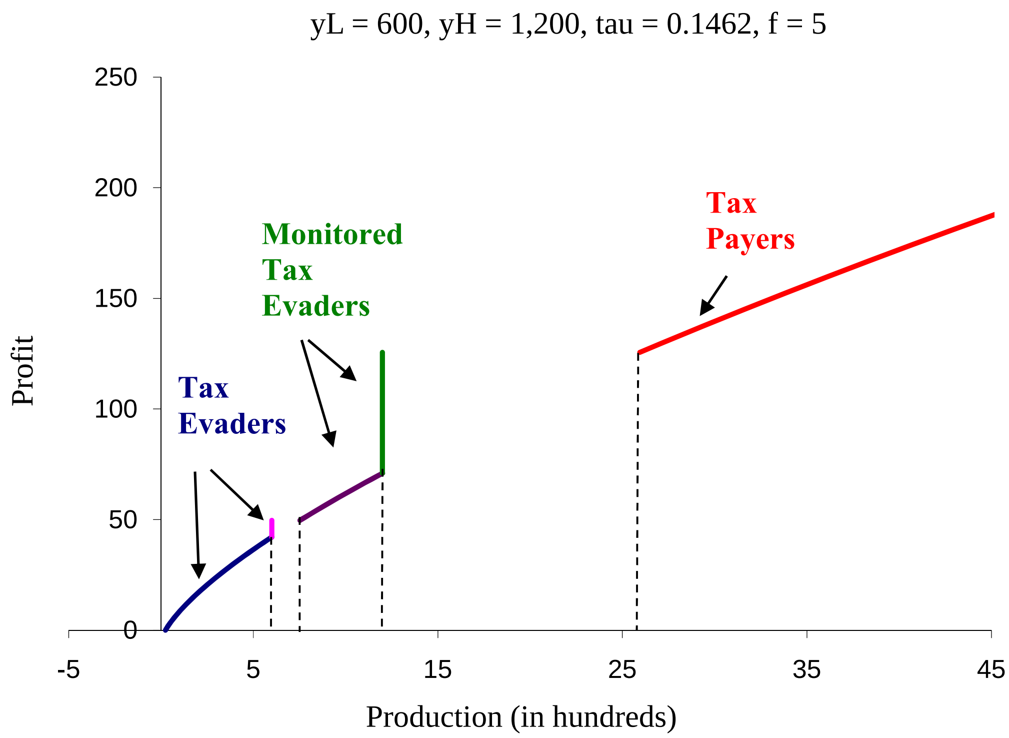


Figure 2. 12 Profit as a function of production for the case of $1-\overline{\mu}=0.02$.

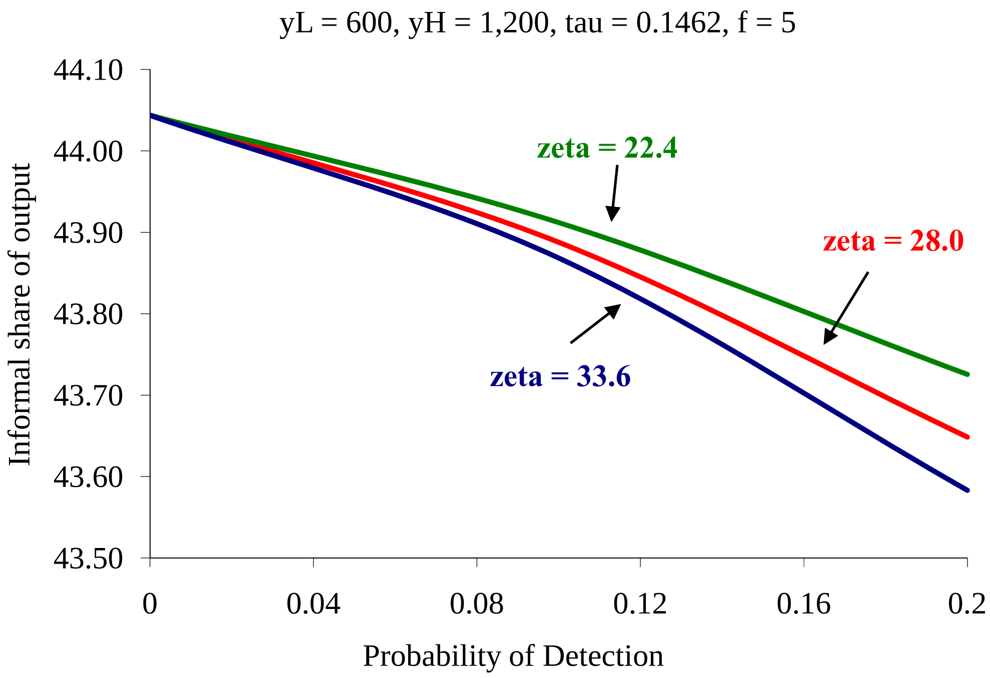


Figure 2. 13 Informal share of output for various levels of penalty costs ζ and probability of detection $1-\overline{\mu}$.

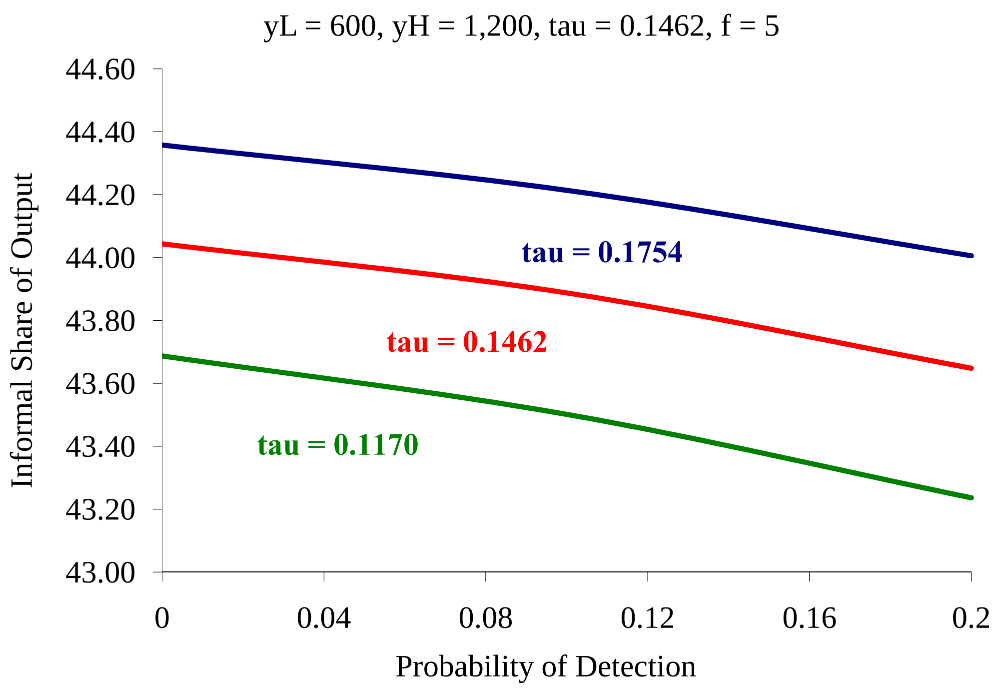


Figure 2. 14 Informal share of output for various levels of tax rates τ and probability of detection $1-\overline{\mu}$.

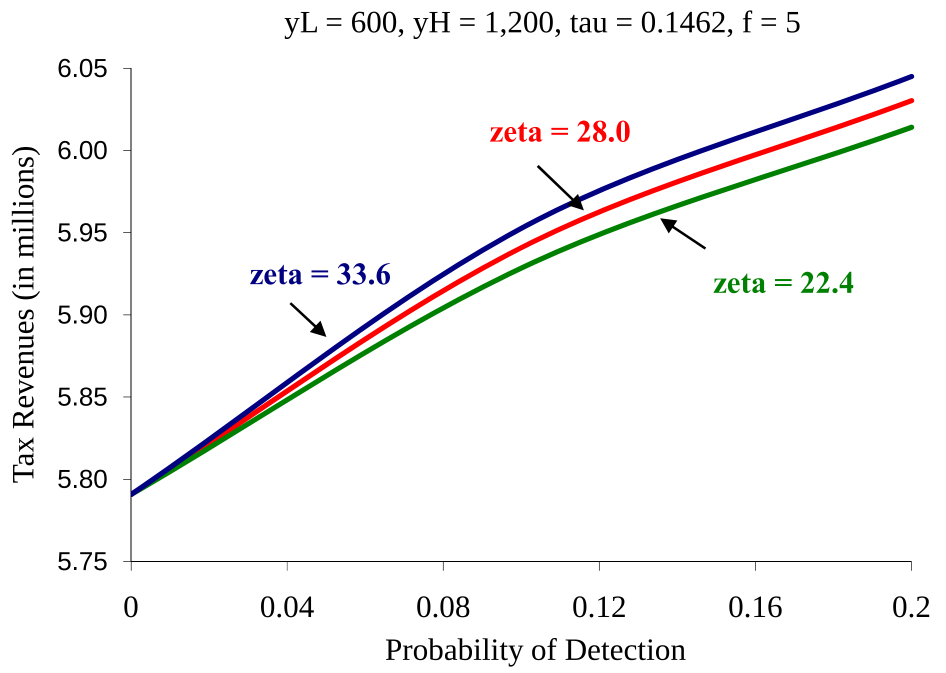


Figure 2. 15 Tax revenues for various levels of penalty costs ζ and probability of detection $1-\overline{\mu}$.

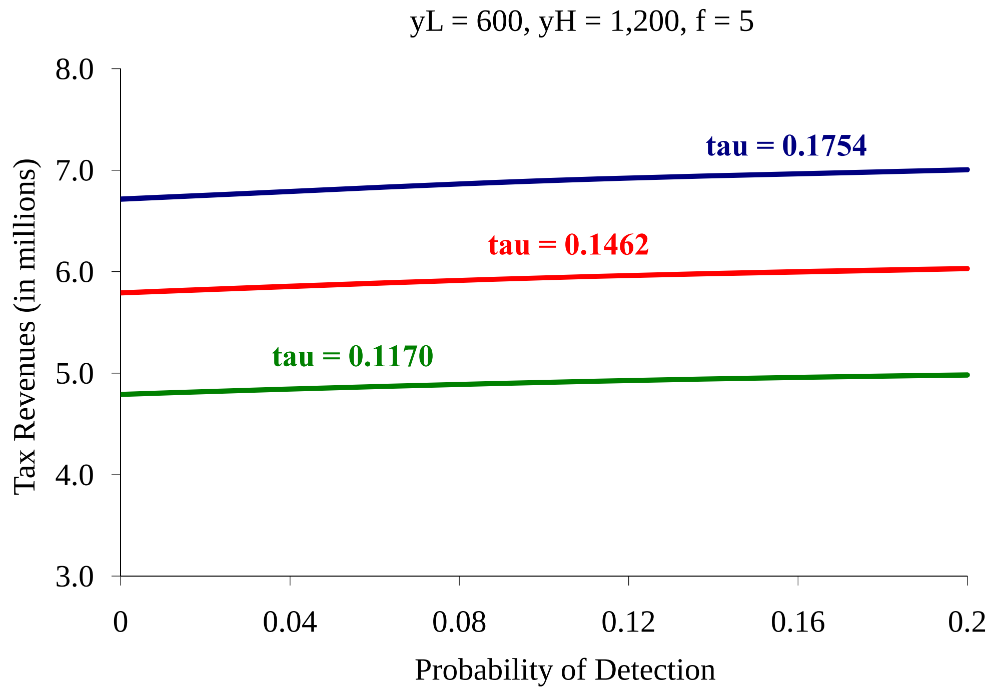


Figure 2. 16 Tax revenues for various levels of tax rates τ and probability of detection $1-\overline{\mu}$.

Appendices to Chapter 3

Appendix A: Tables

Table 3. 1 List of sectors in disaggregated 2003 SAM for Russia

№№	SAM	Input-Output Table
1	Electric Energy	Electric Energy
2	Crude Petroleum Extraction	Crude Petroleum Extraction
3	Petroleum Manufacturing	Petroleum Manufacturing
4	Natural Gas	Natural Gas
5	Coal	Coal
6	Shale Oil and Peat	Shale Oil and Peat
7	Ferrous Metals	Ferrous Metals
8	Non-ferrous Metals	Non-ferrous Metals
9	Chemistry	Chemical and Petrochemical Industry
10	Machinery	Machinery and Equipment, Metalworking Industry
11	Wood	Timber Industry, Woodworking Industry, Pulp, and Paper Industry Products
12	Construction Materials	Construction Materials (Including Glass, Ceramic and Faience Industry)
13	Light Industry	Light Industry
14	Food Industry	Food Industry
15	Other Manufacturing	Other Manufacturing
16	Construction	Construction
17	Agriculture	Agricultural Services and Forestry
18	Transportation	Transportation and Communication Services
19	Finance	Finance, Credit, Insurance, State Administration, Public Associations and Unions
20	Other Services	Trade Services (Including Food Services) Other Activities Dwellings Health, Physical Training and Sport Services and Social Security, Culture and Art, Science and Scientific Services, Geology and Ground and Bowels Investigation, Geodesic and Hydro-Meteorological Services

Table 3. 2 Schematic social accounting matrix

№№	Expenditures / Receipts	Production Goods Sectors	Consumption Goods Sectors	Factors	Households	Government	Capital	Rest of World	Row of Sums
1	2	3	4	5	6	7	8	9	10
1	*Production Goods Sectors*	Intermediate inputs	Intermediate inputs			Government commodity consumption	Investment demands for locally procured commodities	Commodity exports	Total commodity demands
2	*Consumption Goods Sectors*				Household commodity consumption				Total demands for consumption goods
3	*Factors*	Labor inputs, rent, profits, depreciation							Total factor earnings
4	*Households*			Factor payments to households					Household total incomes

Table 3. 2 Continued

1	2	3	4	5	6	7	8	9	10
5	*Government*	Indirect taxes, tariffs	Commodity sales tax		Direct taxes				Government total fiscal receipts
6	*Capital*				Household savings	Government savings (sales of bonds if negative)		Net capital inflow (outflow if negative)	Total capital receipts
7	*Rest of the World*	Commodity Imports							Total payments to outside regions
8	*Column Sums*	Total costs of production of production goods	Total costs of production of consumption goods	Total factor payments	Household expenditures	Total government expenditures	Total investment	Total receipts from the rest of the world	Total transactions

Table 3. 3 Import and export elasticities of substitution $(\rho_{x,j}, \rho_{m,j})$ for Russia

Sectors	Uniform Values		Differentiated Values	
	Case 1		Case 2	
	$\rho_{x,j}$	$\rho_{m,j}$	$\rho_{x,j}$	$\rho_{m,j}$ *)
Electricity	0.9	0.8	0.9	0.750
Crude Petroleum Extraction	0.9	0.8	0.9	0.750
Petroleum Manufacturing	0.9	0.8	0.9	0.750
Natural Gas	0.9	0.8	0.9	0.750
Coal	0.9	0.8	0.9	0.750
Shale Oil and Peat	0.9	0.8	0.9	0.750
Ferrous Metals	0.9	0.8	0.9	0.806
Non-ferrous Metals	0.9	0.8	0.9	0.806
Chemicals	0.9	0.8	0.9	0.827
Machinery	0.9	0.8	0.9	0.587
Wood	0.9	0.8	0.9	0.800
Construction Materials	0.9	0.8	0.9	0.800
Light Industry	0.9	0.8	0.9	0.940
Food Industry	0.9	0.8	0.9	0.789
Other Manufacturing	0.9	0.8	0.9	0.800
Construction	0.9	0.8	0.9	0.600
Agriculture	0.9	0.8	0.9	0.607
Transportation	0.9	0.8	0.9	0.600
Finance	0.9	0.8	0.9	0.590
Other Services	0.9	0.8	0.9	0.600

*) Source: Alekseev (2003)

Table 3. 4 Tariff rates (τ_j) - the Russian Federation (in percentage terms, %)

Sectors	Tariff Rates	Sectors	Tariff Rates
Electricity	5.00	Wood	13.10
Crude Petroleum Extraction	5.00	Construction Materials	13.80
Petroleum Manufacturing	5.00	Light Industry	22.10
Natural Gas	5.00	Food Industry	25.80
Coal	5.00	Other Manufacturing	10.70
Shale Oil and Peat	5.00	Construction	0.00
Ferrous Metals	9.60	Agriculture	16.00
Non-Ferrous Metals	14.70	Transportation	0.00
Chemicals	9.10	Finance	0.00
Machinery	11.00	Other Services	0.00

Source: The World Bank

Table 3. 5 Tariff rates (τ_j^f) - the rest of the world (in percentage terms, %)

Sectors	Tariff Rates	Sectors	Tariff Rates
Electricity	0.34	Wood	8.80
Crude Petroleum Extraction	0.50	Construction Materials	10.62
Petroleum Manufacturing	4.46	Light Industry	13.95
Natural Gas	0.50	Food Industry	21.92
Coal	2.60	Other Manufacturing	8.08
Shale Oil and Peat	6.24	Construction	0.00
Ferrous Metals	5.73	Agriculture	9.58
Non-Ferrous Metals	3.97	Transportation	0.00
Chemicals	5.63	Finance	0.00
Machinery	7.14	Other Services	0.00

Source: By construction using Table 6.1 from the GTAP 6 Data Base, December 2006

Table 3. 6 Effect of partial liberalization on domestic prices and total domestic production (in billions of rubles)

Sectors	Benchmark		Case 1		Case 2	
	Prices	Output	Prices	Output	Prices	Output
Electricity	1	939.89	0.9964	939.37	0.9944	938.80
Crude Petroleum Extraction	1	1,454.06	0.9898	1,455.04	0.9812	1,455.13
Petroleum Manufacturing	1	1,211.57	0.9982	1,205.88	0.9947	1,205.75
Natural Gas	1	881.76	0.9919	880.38	0.9810	879.19
Coal	1	308.77	0.9944	307.92	0.9862	308.33
Shale Oil and Peat	1	2.32	0.9947	2.32	0.9889	2.32
Ferrous Metals	1	858.46	0.9961	836.56	0.9925	837.57
Non-ferrous Metals	1	832.77	0.9957	811.11	0.9924	811.72
Chemicals	1	698.38	0.9970	653.76	0.9930	650.16
Machinery	1	1,750.36	0.9984	1,582.78	0.9964	1,667.95
Wood	1	487.71	0.9964	459.73	0.9923	461.26
Construction Materials	1	405.17	0.9964	380.71	0.9919	381.97
Light Industry	1	99.95	0.9979	64.86	0.9940	23.19
Food Industry	1	1,507.39	0.9967	1,291.59	0.9936	1,305.90
Other Manufacturing	1	261.15	0.9980	251.38	0.9963	251.57
Construction	1	1,829.35	0.9954	1,828.70	0.9929	1,824.07
Agriculture	1	1,261.42	0.9961	1,233.25	0.9934	1,247.75
Transportation	1	1,500.60	0.9963	1,501.14	0.9966	1,498.23
Finance	1	1,944.73	0.9965	1,944.47	0.9934	1,941.92
Other Services	1	7,517.33	0.9921	7,565.29	0.9872	7,498.66

Table 3. 7 Effect of partial liberalization on domestic production (in percentage terms, %)

Sectors	Case 1	Case 2
Electricity	-0.06	-0.12
Crude Petroleum Extraction	0.07	0.07
Petroleum Manufacturing	-0.47	-0.48
Natural Gas	-0.16	-0.29
Coal	-0.28	-0.14
Shale Oil and Peat	-0.06	-0.04
Ferrous Metals	-2.55	-2.43
Non-ferrous Metals	-2.60	-2.53
Chemicals	-6.39	-6.90
Machinery	-9.57	-4.71
Wood	-5.74	-5.42
Construction Materials	-6.04	-5.73
Light Industry	-35.11	-76.80
Food Industry	-14.32	-13.37
Other Manufacturing	-3.74	-3.67
Construction	-0.04	-0.29
Agriculture	-2.23	-1.08
Transportation	0.04	-0.16
Finance	-0.01	-0.14
Other Services	0.64	-0.25

Table 3. 8 Effect of partial liberalization on exports and imports (in billions of rubles)

Sectors	Export					Import				
	Benchmark	Case 1		Case 2		Benchmark	Case 1		Case 2	
		Data	Change	Data	Change		Data	Change	Data	Change
Electricity	16.17	15.75	-2.60	15.81	-2.19	5.23	5.94	13.59	5.75	10.00
Crude	1,198.33	1,082.25	-9.69	1,011.39	-15.60	14.95	16.46	10.04	15.62	4.46
Petroleum	438.99	503.38	14.67	487.88	11.14	34.40	39.27	14.16	37.74	9.72
Natural Gas	528.93	413.24	-21.87	402.61	-23.88	5.68	6.30	10.93	5.90	4.02
Coal	52.86	56.97	7.78	56.63	7.13	6.81	7.64	12.20	7.24	6.37
Shale Oil and	0.47	0.60	28.01	0.60	27.33	0.01	0.01	12.64	0.01	7.67
Ferrous	332.51	408.67	22.90	399.11	20.03	92.73	113.73	22.65	112.88	21.73
Non-ferrous	459.51	513.77	11.81	497.16	8.19	56.75	77.10	35.85	76.87	35.44
Chemicals	265.66	327.32	23.21	325.40	22.49	241.29	283.11	17.33	285.91	18.49
Machinery	408.14	534.41	30.94	517.08	26.69	818.31	970.74	18.63	886.15	8.29
Wood	162.85	231.35	42.06	228.38	40.24	90.20	115.70	28.27	114.01	26.40
Construction	14.66	22.84	55.87	22.79	55.53	63.61	85.87	35.00	84.49	32.82
Light Industry	38.26	68.99	80.30	70.98	85.49	490.16	519.92	6.07	553.56	12.93
Food Industry	137.99	334.97	142.75	334.00	142.04	372.23	552.67	48.48	536.50	44.13
Other	53.50	74.14	38.57	73.48	37.34	35.84	44.90	25.27	44.65	24.59
Construction	55.81	53.55	-4.04	54.15	-2.97	127.01	127.31	0.23	126.16	-0.67
Agriculture	44.29	66.57	50.29	67.22	51.77	63.00	88.57	40.59	74.55	18.34
Transportation	200.94	196.72	-2.10	206.32	2.68	46.86	47.21	0.77	47.05	0.41
Finance	9.91	9.46	-4.55	9.45	-4.70	33.21	33.48	0.80	33.08	-0.39
Other Services	236.09	243.68	3.21	275.80	16.82	555.64	551.35	-0.77	544.32	-2.04

Table 3. 9 Effect of partial liberalization on change in welfare (in percentage terms, %)

Types of Welfare	Uniform Values	Differentiated Values
	Case 1	Case 2
Consumer Welfare	-2.13	-2.87
Government Welfare	0.39	0.98
Social Welfare	-1.70	-2.22

Table 3. 10 Effect of complete liberalization on domestic prices and total domestic production (in billions of rubles)

Sectors	Benchmark		Case 1		Case 2	
	Prices	Output	Prices	Output	Prices	Output
Electricity	1	939.89	0.9952	939.94	0.9968	940.29
Crude Petroleum Extraction	1	1,454.06	0.9917	1,456.97	0.9958	1,457.06
Petroleum Manufacturing	1	1,211.57	1.0011	1,199.22	1.0025	1,201.83
Natural Gas	1	881.76	1.0001	880.48	1.0034	881.20
Coal	1	308.77	1.0014	306.03	1.0037	306.45
Shale Oil and Peat	1	2.32	0.9978	2.32	1.0001	2.32
Ferrous Metals	1	858.46	0.9976	801.58	0.9993	795.76
Non-ferrous Metals	1	832.77	0.9957	774.98	0.9977	769.41
Chemicals	1	698.38	0.9996	590.47	1.0011	565.37
Machinery	1	1,750.36	1.0005	1,368.34	1.0013	1,567.12
Wood	1	487.71	0.9989	418.27	1.0005	415.31
Construction Materials	1	405.17	0.9994	350.92	1.0010	348.67
Light Industry	1	99.95	1.0004	37.26	1.0011	2.82
Food Industry	1	1,507.39	0.9982	992.72	0.9994	1,013.38
Other Manufacturing	1	261.15	0.9986	237.06	0.9995	235.98
Construction	1	1,829.35	0.9943	1,830.37	0.9962	1,833.69
Agriculture	1	1,261.42	0.9959	1,188.90	0.9975	1,231.31
Transportation	1	1,500.60	0.9916	1,506.09	0.9931	1,506.95
Finance	1	1,944.73	0.9975	1,947.37	0.9990	1,948.82
Other Services	1	7,517.33	0.9904	7,733.60	0.9936	7,737.49

Table 3. 11 Effect of complete liberalization on exports and imports
(data in billions of rubles, change in percentage terms, %)

Sectors	Export					Import				
	Benchmark	Case 1		Case 2		Benchmark	Case 1		Case 2	
		Data	Change	Data	Change		Data	Change	Data	Change
Electricity	16.17	13.81	-14.57	13.26	-17.98	5.23	7.17	37.15	6.88	31.59
Crude	1,198.33	998.38	-16.69	974.15	-18.71	14.95	20.19	35.05	19.63	31.29
Petroleum	438.99	549.75	25.23	532.16	21.22	34.40	48.09	39.80	45.93	33.50
Natural Gas	528.93	451.00	-14.73	436.52	-17.47	5.68	7.97	40.35	7.66	34.98
Coal	52.86	56.28	6.48	54.22	2.57	6.81	9.54	40.20	9.13	34.20
Shale Oil and	0.47	0.71	51.17	0.69	45.66	0.01	0.01	38.72	0.01	33.07
Ferrous	332.51	469.80	41.29	454.72	36.75	92.73	148.90	60.58	154.59	66.71
Non-ferrous	459.51	548.66	19.40	532.01	15.78	56.75	112.98	99.07	118.25	108.35
Chemicals	265.66	373.48	40.58	359.89	35.47	241.29	346.46	43.59	371.27	53.87
Machinery	408.14	652.90	59.97	633.43	55.20	818.31	1,189.71	45.39	1,000.26	22.23
Wood	162.85	308.85	89.66	298.09	83.05	90.20	156.71	73.73	159.78	77.14
Construction	14.66	33.18	126.38	31.90	117.64	63.61	115.38	81.39	117.73	85.08
Light Industry	38.26	115.70	202.37	111.68	191.85	490.16	546.94	11.59	575.28	17.37
Food Industry	137.99	803.25	482.09	777.20	463.22	372.23	842.40	126.31	825.70	121.82
Other	53.50	95.75	78.96	92.30	72.52	35.84	59.11	64.93	60.23	68.05
Construction	55.81	45.82	-17.91	43.92	-21.31	127.01	135.97	7.05	133.56	5.15
Agriculture	44.29	91.08	105.62	87.38	97.28	63.00	134.47	113.45	94.49	49.99
Transportation	200.94	163.00	-18.88	154.32	-23.20	46.86	49.62	5.90	48.98	4.53
Finance	9.91	8.19	-17.35	7.87	-20.60	33.21	36.16	8.88	35.11	5.71
Other Services	236.09	189.10	-19.91	176.14	-25.39	555.64	599.74	7.94	596.06	7.27

Table 3. 12 Effect of complete liberalization on change in welfare
(in percentage terms, %)

Types of Welfare	**Uniform Values**	**Differentiated Values**
	Case 1	**Case 2**
Consumer Welfare	-3.54	-2.65
Government Welfare	-0.13	-0.29
Social Welfare	-2.96	-2.25

Table 3. 13 Government revenue structure (in percentage terms, %)

Types of Tax Revenue	**Benchmark**	**Partial Liberalization**		**Complete Liberalization**	
		Case 1	**Case 2**	**Case 1**	**Case 2**
Tax Revenue from Production	-5.80	-3.38	-1.78	-0.88	0.32
Direct Tax Revenue	11.62	11.37	11.29	11.22	11.32
Tax Revenue from Consumption	22.49	22.01	21.84	21.71	21.91
Tariff Revenue	15.93	9.80	9.61	0.00	0.00
Total Bonds Holdings	20.15	20.15	20.15	20.15	20.15
Tax Revenue from Exports	35.61	40.04	38.90	47.81	46.30
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Appendix B: Figures

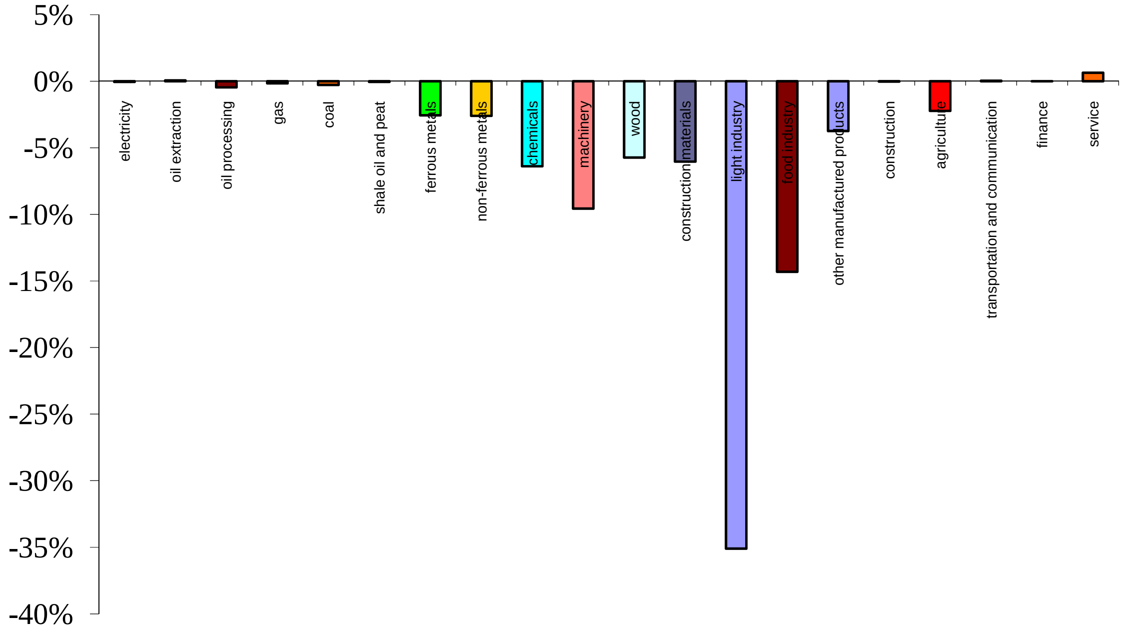


Figure 3. 1 Changes in Russian domestic production by sectors if $\rho_{m,j} = 0.8$, $\rho_{x,j} = 0.9$ for all j.

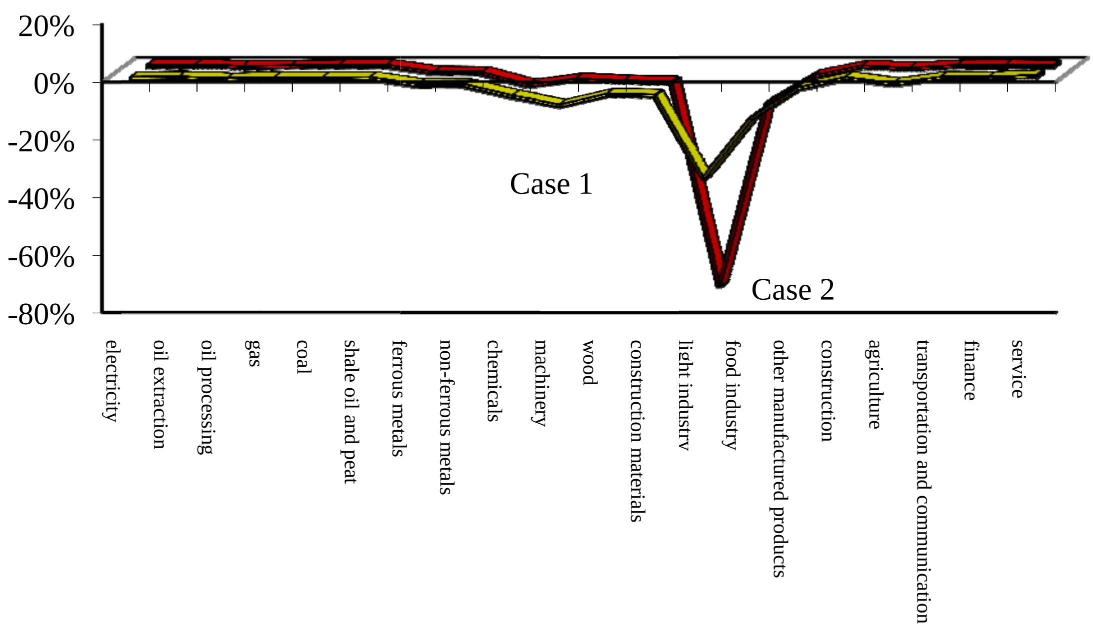


Figure 3. 2 Effect of partial liberalization on Russian domestic production.

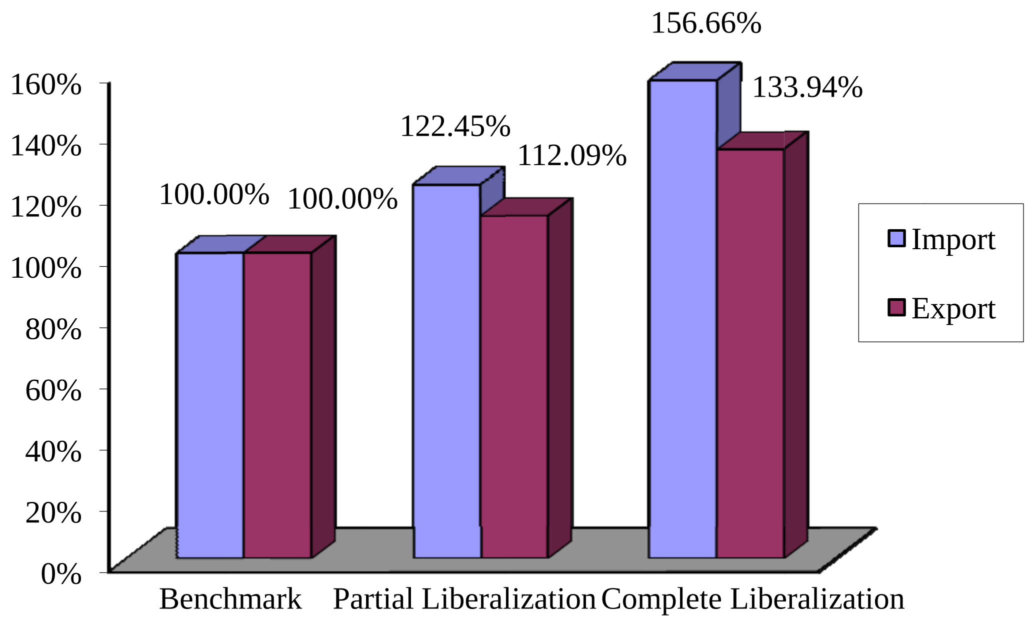


Figure 3. 3 Effect of trade liberalization on exports and imports excluding services and construction.