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AN EXPENDITURE-BASED ESTIMATE OF LATVIA'S SHADOW ECONOMY

Authors: Renata Bernotaitė
Anastasija Piskunova

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An Expenditure-Based Estimate of Latvia's Shadow Economy

By

Renata Bernotaitė (renata.bernotaite@gmail.com)

Anastasija Piskunova (anastasijap@gmail.com)

Supervised by

Vyacheslav Dombrovsky

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Stockholm School of Economics in Riga

Abstract

This paper deals with estimation of income underreporting in Latvia using Household Budget Survey data. The estimate obtained is employed to calculate the size of the shadow economy (defined as *the value of economic activity were it reported to the tax authorities* within the scope of this paper) in Latvia in year 2003. The underlying idea is to infer the extent of income underreporting from data on food expenditure of households. Herein the applied method is based on the study carried out by Pissarides and Weber to assess the size of Britain's informal economy. The research relies on working assumptions that all individuals in the survey report their expenditure on food correctly; that public sector employees report their income accurately; and that the private sector underreports their income in Latvia. Using regression analysis, the food expenditure equation is estimated and then inverted to arrive at the coefficient of income underreporting. The authors find that true income of the private sector is 1.901 times as much as the amount that is reported. This means that the size of the shadow economy in Latvia from the income underreporting perspective is around 20.8% of GDP.

1. Introduction

The problem of the shadow economy, which has become especially prominent in transition countries, has been on the top of the agenda for many countries around the world. The main reason the informal economy is a concern for decision makers is its detrimental effect on the national accounts, on the basis of which inappropriate fiscal and monetary policies are made. Failure to correctly measure and recognize the size of the shadow economy can result in an inefficient implementation of social welfare programs, and even lead to political imbalance, where GDP levels are used in allocating credits from IMF or regional banks, to assess whether countries meet EU criteria, and to set the size of the members' contributions to the EU budget (Fleming, Roman, and Farrell, 2000, 393). The competitive situation in the country can be impaired by existing informal economic activities, as a result of rational actors moving to the shadow economy to escape the high entry costs to legality, such as license fees and registration requirements and the high costs of remaining legal (Loayza, 2000). Realization of the importance of the problem served as premise for the authors' *aim to estimate the size of the shadow economy in Latvia by applying an expenditure-based method, which is new to the country.*

Some part of the shadow economy is productive in its nature and could be captured in the official accounts. However, its other component represents benefit fraud and tax evasion and normally can not be incorporated in the national statistics. According to the latest economic researches, the most pronounced problem pertaining to the shadow economy in Latvia is tax evasion in the form of salaries paid in "envelopes" (Renoy et al, Visnevskis and Parups). On these grounds, within the scope of this research the shadow economy should be understood as "*the value of economic activity that would be taxable were it reported to the tax authorities"* (qtd. in Strasberg, 2004, 6-7).

Many methods have been developed to estimate the extent of the shadow economy. They can be divided into two broad groups: indirect and direct methods. The direct approaches are meant to measure the extent of the shadow economy from data collected by directly asking selected individuals about their non-compliance with the tax authorities or about their income from informal activities. The indirect methods grasp the extent of the shadow economy by examining discrepancies between reported and unreported activities, or forecasted demand and actual demand of certain economic activities, which are then used to generate an estimate of the overall size of the shadow economy. The most often applied indirect approaches to estimate the extent of the shadow economy are the following seven methods: *national*

expenditure and income method, labour force statistics, transactions approach method, currency demand, electricity consumption, dynamic multiple-indicators multiple-causes, and *the expenditure-based method*.

The appropriateness of each of these approaches is assessed depending on the nature of the shadow economy in a particular country. Up till now, consensus on a single suitable one has not been achieved. Methods used to estimate the extent of the shadow economy in Latvia vary as well. Available estimates range from 15% to 43% of GDP for different periods of time. Why then is there a need for another estimate? Firstly, the more different estimates are available, the more comprehensive is the view on the phenomenon in the country. Secondly, the previous estimation approaches were not originally designed to measure the extent of income underreporting and the size of the shadow economy in the form of tax evasion, which is the true problem in Latvia. The expenditure-based method has an advantage over the others since it captures the problem of tax evasion and income underreporting and, therefore, is of academic and practical interest for the country.

The estimation of the level of income underreporting in Latvia is based on the expenditure-based method, which was originally employed by Pissarides and Weber in the UK in 1989. Household Budget Survey data collected by the Central Statistical Bureau of Latvia for the year 2003 is used in the research. The applied method relies on several underlying assumptions. The first states that all households correctly report their expenditure on food, since people would not purposely hide their expenditure on food from fear of accusation of tax evasion. The second assumption is that income is correctly reported by those employed in the public sector, whereas the self-employed and employees in the private sector tend to underreport their income. Accordingly, the food consumption function is estimated, which then is inverted to arrive at the coefficient of income underreporting. The estimate obtained of the extent of underreporting is then used to calculate the size of the of shadow economy as a percentage of GDP.

The authors arrive at the estimate of income underreporting equal to 1.901. This implies that the size of the shadow economy in Latvia is around 21 percent of GDP. The finding is comparable to the available estimates of Latvia's shadow economy obtained by other researchers for the period of interest.

By applying a new (for Latvia) expenditure-based method, the authors make a certain contribution to society by tackling the problem of indirect measurement of economic activity in the country. Based on the results gained by exploiting the expenditure-based method, not only the necessary adjustment of the GDP due to the shadow economy is shown, but also an

estimate of Latvia's informal economy constituted by tax evasion in the form of salaries in "envelopes" is obtained. Application of the new method can be perceived as a more careful look taken from a different perspective into the problem of informal activities in the country.

The paper is organized as follows. The following section starts with a discussion on the phenomenon of the shadow economy and its definition, leading to the problem of tax evasion in general and in the case of Latvia. After a rigorous explanation of the methodology and data description, the authors present their estimation results. Concluding remarks on the findings and the implications of the current work for further research finalize the paper.

2. The Shadow Economy in Latvia

The aim of the current section is to provide a deeper insight into the phenomenon of the shadow economy at large and in the context of a country's national accounts. By uncovering the form of the shadow economy that is significant for Latvia, the justification for the focus of the paper and for the choice of the method to estimate the phenomenon is outlined. To strenghthen the arguments presented, the section concludes with a discussion on the variety of estimates on the level of the shadow economy in Latvia done so far.

2.1. Defining Shadow Economy

Measurement of the value of economic activities has always been quite a challenging task since it is fairly complicated to capture and quantify all the sources contributing to the size of the economy. For that reason, the problem of measuring GDP is usually tackled from different perspectives by exploiting *the expenditure-based method, the income method* and *the output method*. To arrive at the final figure of GDP, the statistics on national accounts are typically compiled and cross-checked from various sources. Thus, some activities that fall into the category of the informal economy and are concealed from the tax authorities and, thus, escape the conventional income measure may well show up in, for instance, expenditure estimates (Cowell, 1990, 16). As a result, some part of the shadow economy is accounted for in GDP measures, whereas the size of a large part of it still needs to be estimated separately. Nevertheless it should be noted that depending on the historical background, certain characteristics and the problems the country is faced with, the composition and nature of the shadow economy will tend to vary across countries.

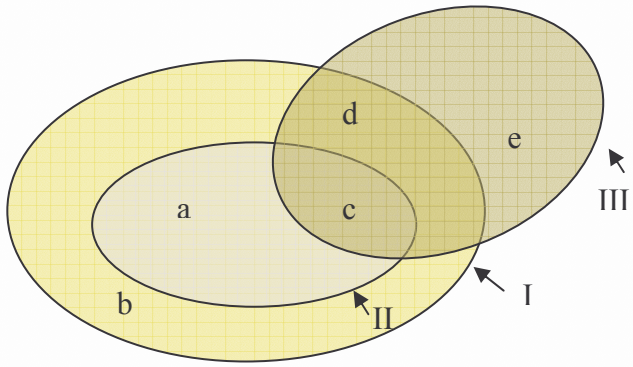

Figure 1. *The scope of the shadow economy***.** Note: a – legal official production, private and public sectors; b – housework, do-it-yourself work, voluntary organizations; c – shadow economy allowed for in official accounts; d – shadow economy not allowed for in official accounts; e – benefit fraud and evasion outside the production sector. I, II, III – boundaries discussed in text. *Source:* "Cheating the Government: The Economics of Evasion", Frank Cowell (1990)

Issues of the shadow economy can be viewed within the framework created by Frank A. Cowell (1990), depicted in Figure 1. Here, boundary I separates transactions comprising production from those that are not productive. Boundary II represents the *official production* boundary. It determines what actually appears in a country's national accounts. Because official statistics are somewhat stricter in deciding what constitutes official production and what does not, the area within boundary II lies wholly inside the area delimited by Boundary I. Therefore, there would always be an unofficial sector, even if everybody were absolutely honest when reporting their income and activities they are engaged in. Finally, the area inside boundary III represents the shadow economy. From the scheme it can be seen that there are basically three parts of the informal economy: first (area c) allowed for in the official accounts, second (area d) not allowed in the national accounts. However, both these parts can be captured in the national accounts since national statistics are gathered from various sources and cross-checked. The last portion of the shadow economy (area e) lies outside the production boundary and represents, for example, benefit fraud and the evasion of taxes on the transfer of capital.

Considering the variety of the sources from which the shadow economy can emerge and accepting the inability to grasp all of them, the authors of this paper focus on the shadow economy in the form of tax evasion. Thus, the term *shadow economy* within the scope of the current research will be understood as "*the value of economic activity that would be taxable were it reported to the tax authorities*" proposed by Brooks (qtd. in Strasberg, 2004, 6-7), particularly delimiting the definition to tax evasion in the form of unreported income

obtained as "wages in envelopes" from self-employment and employment in the private sector. This falls into the category of the legal type of underground economic activity as specified by Lippert and Walker (qtd. in Schneider, 2002, 2).

Since the paper attempts to estimate the size of the shadow economy in the form of tax evasion, the justification for this is provided below, highlighting that tax evasion in Latvia is considered to be a serious problem.

2.2. Tax Evasion in Latvia

As in many other transition countries the problem of the portion of the shadow economy representing benefit fraud and tax evasion is quite pronounced in Latvia relative to other possible parts comprising the country's shadow economy. The problem of tax evasion evolved during the period of transition, when the country was faced with the need to establish itself institutionally in a way that would facilitate restructuring of the economy, the processes of privatization, and stabilization. During that period, the role of the government declined for two primary reasons: first being its inability to collect the same level of revenues as before due to the fall of former budget revenue funding principles and, second, the impulsive explosion of the shadow economy (Viktor Trasberg, 2004, 11). Building the system for tax collection was a hard task and the institutions of tax administration were frequently powerless faced with the unprecedented growth of the informal sector. There was little success in inducing private enterprises to correctly report on their true incomes, which resulted in extensive tax evasion (2004, 12).

In the recent report of the European Commission on "Undeclared Work in an Enlarged Union" Latvia is classified as a country having a medium level of undeclared work (14-23%), being a "post-Soviet country that implemented reforms slower than many of its Central and Eastern European neighbours, having a more deep-rooted Soviet-type bureaucracy and a more backward economic structure" (Renoy et al, 2004, 28). As argued in the same paper with regard to the situation in Latvia, "the typical form of undeclared work is a worker who gets a small wage (subject to minimum taxes) and the rest in an "envelope". Firms have little motivation to seek fully unregistered labour since that may arouse suspicions of the tax authorities (too few workers relative to turnover), which would lead to tax audit. Rather, it is underreporting of income that is prevalent" (2004, 128).

In the results of their investigation, Schneider and Neck found that the complexity of the tax system has a negative correlation with the extent of tax evasion. Moreover, it is considered that such psychological reasons as tax morale and perceived fairness of the tax

system affect the amount of underreporting to the tax authorities. For instance, there is a widespread belief that the scale of tax evasion in Scandinavian countries is small due to the tax morale of people there (Schneider, 2000, 82).

The interplay between the factors affecting the decision to evade taxes could be illustrated by Rosen's model of tax evasion, a graphical representation of which can be found in Appendix 1. Here, the decision of the individual on whether to evade taxes or not is considered to depend on two factors – the degree of tax burden (t) and the expected penalty (MC = marginal cost). Every unit of currency of income not reported to the authorities raises the income of the tax-payer by t, which is defined as marginal benefit. The expected penalty, MC, is determined by the probability of being caught and the established penalty for evading taxes. The equilibrium amount of tax evasion (R^*), therefore, depends on the magnitude of the above-discussed factors. The intuition behind the model is that the higher the tax rate, the greater is the benefit of evading it. But increased probability of being detected and higher penalty would lower the equilibrium amount of tax evasion. Theoretically, the two may be so high that would lead to the situation where tax evasion is not beneficial at all (1999, 329).

The factors predicted by theory and the findings of Schneider and Neck seem to be credible in explaining the situation in Latvia. Further on, some more propositions for possible factors explaining tax evasion in Latvia are made:

1. The perceived "cost" of getting caught is smaller than the benefit of not paying such taxes as corporate tax, social tax, and income tax.
2. Evasion reason for employees is the combination of high social taxes, preference for current consumption, and low income.
3. The mutually beneficial collusion of employees and employers on evading social and income taxes.
4. The Soviet past, when evasion of pervasive state regulation was considered to be a norm.
5. About 1/5 of the population of Latvia being non-citizens employed in the private sector, who might well feel little or no commitment to comply with social rules, among which is paying taxes (Renoy, 2004, 127-128).

The above presented arguments sound particularly plausible in the light of the findings of Visnevskis and Parups, demonstrating that social tax in Latvia is a major determinant of "wages in envelopes", which have a certain contribution to the shadow economy at large (2004, 34). And since tax evasion as a part of the shadow economy is considered to be a substantial problem in Latvia, its measurement should be treated seriously and cautiously.

2.3. Measuring the Shadow Economy in Latvia

A number of works are devoted to measuring the shadow economy exclusively in Latvia. Nevertheless, the country more often appears in works on a large number of states, and is usually mentioned in the context of transition countries. As the methods exploited for measuring the size of the shadow economy in Latvia vary among authors, so tend to do the estimates for particular periods. A summary of available estimation results is presented in Table 1 and is in turn briefly discussed.

The most recent estimate of the shadow economy in Latvia was made by Edgars Brēķis in 2004. He applied a money demand approach and found that the shadow economy in Latvia was around 29 percent in 1995, 19-20 percent in 2002 and 21 percent in the middle of 2003. Alternatively, the physical input method employed by Johnson et al gives somewhat higher results for the period 1994-1995, the average being 34.8 percent (qtd in. Schneider, 2000). The estimates produced using the electricity consumption approach, which was employed by Lackó to measure the shadow economy in transition countries, show that the shadow economy was around 43.4 percent in 1994-1995 (qtd in. Schneider, 2000).

The DYMIMIC method, which is a model allowing accounting for multiple indicators and multiple causes, has also been applied for estimating the shadow economy in the transition countries and former Soviet Union states. Using this method, Schneider finds the informal economy in Latvia to be on average 25.7 percent in 1990-1993 and 39.6 percent in 2000-2001 (2003). He also estimates that the labour force involved in unofficial economy was around 29.6 percent of the working age population in 1998-1999.

Officially the shadow economy in Latvia is measured by the Central Statistical Bureau (CSB) based on information about the difference between employment of people as reported in the Enterprise Survey and the Labour Force Survey (Renoy et al, 2004). The interesting fact is that the estimates obtained by the CSB of Latvia are lower than the ones previously mentioned. For example, according to the CSB the proportion of the shadow economy in 1997-2002 was relatively constant, being around 16-17 percent of GDP evaluating it from the manufacturing perspective (Sustainable Development Indicators in Latvia, 2003). Referring to the same source of estimates, in 2000 about 23 percent of the employed workforce was in unregistered employment (Renoy et al, 2004).

Author/Method	Period (Estimate as a percentage of GDP)					
Edgars Brēķis/ Money Demand Approach		1995 (29%)			2002 (19-20%)	2003 (21%)
Johnson et al/ Physical Input Method	1990-1993 (24.3%)	1994-1995 (34.8%)				
Lackó/ Electricity Consumption Approach	1990-1993 (32.2%)	1994-1995 (43.4%)				
Schneider/ DYMIMIC Method	1990- 1993 (25.7%)			2000-2001 (39.6%)		
CSB of Latvia/ Information on employment from LFS and Enterprise Register		1995 (15%)	1996-1999 (16.5%)	2000-2001 (17.5%)		

Table 1. *Estimates of the shadow economy in Latvia produced by different authors and employing various methods.*

All measurements made differ to some extent due to the type of the methodology applied. However, it still provides some kind of benchmark range of values for the phenomenon under consideration within different time frames. At the same time, it leaves some space for speculation on the actual level of shadow activities in Latvia.

It should be noted that none of the methods previously employed in Latvia embarked directly on an estimation of the extent of tax evasion. The expenditure-based method applied in this research allows approaching the problem of income underreporting using Household Budget Survey data, thereby filling this gap. All together - the mentioned advantage of the method, the perceived importance of the tax evasion problem, as well as the above-discussed discrepancies in already available estimates of the size of the shadow economy for particular periods in Latvia - served as primary incentives for the authors to employ a new (for the country) method.

3. Methodology

With the purpose of estimating the size of the shadow economy in Latvia, the authors proceeded with the expenditure-based method, which is used to estimate the level of the shadow economy in the form of tax evasion. It is based on two assumptions. Firstly, it is assumed that there is some item, for example food, the expenditure on which is reported correctly by all households in the country. Secondly, it is assumed that there is an identifiable group of households that accurately reports their income to the authorities. A food consumption function is estimated for the correctly and incorrectly reporting groups controlling for various household characteristics, which is then inverted to obtain a “correct”

level of income for the income underreporting group. The result obtained of the extent of underreporting is then used to arrive at the size of the shadow economy expressed as a percentage of GDP.

The method was introduced by Pissarides and Weber, who estimated the size of the shadow economy in Great Britain. Later on it was used by Baker (1993) and Cullinan (1997) and most recently applied by Johansson (2000) for Finland for the period from 1994 to 1996. It should be noted that, although the method is not a novel one, it is useful in terms of its approach to the problem of underreporting. This makes it fairly applicable for the case of Latvia, the reasoning for which is provided in the upcoming part of the paper.

Certain deviations from the original technique had to be made and dealt with, however. For simplicity and better comprehension of the essence of the method, first, a simplified model is introduced in the following part of the paper covering the research methodology. The simple model is later complicated by introducing (or loosening) several crucial assumptions and, thus, gradually arriving at the final model. Before proceeding with the presentation of the method, a more specific research question underlying the earlier presented aim of the paper is presented.

3.1. Research Question

The issue of income underreporting in Latvia, in particular by the private sector, was highlighted in the Quarterly Review of the Baltic Economies of Sampo bank plc. A fact of particular interest pointed to there is that "the wages in Latvia are the lowest in the Baltic countries and now also in the whole European Union. Strange it may seem but, according to statistics, wages paid in the private sector are 15 percent lower than those in the public sector – so called "wages in envelopes" are still popular in Latvia" (Basharova and Titova, 2004). This implies underreporting of income by the private sector. Therefore, smaller wages are reported to the tax authorities in Latvia, whereas part of actually obtained income is paid in "envelopes". On the premises of this argument the research question behind the aim of the paper - which is to apply an expenditure-based method in estimating the size of the shadow economy in Latvia - was raised. It is posed as follows: *Whether food expenditure of private sector households is higher than that of public sector households, controlling for the factors determining the level of income and food consumption of households?*

3.2. Expenditure-based method

3.2.1. Simple model

Following the original expenditure-based method, the technique applied in assessing the size of the shadow economy in Latvia is based on two underlying assumptions:

1) The reporting of expenditure on some items by all groups in the population is correct;
2) The reporting of income by some groups in the population is correct.

Regarding the first assumption, the correctly reported item of expenditure is considered to be food[1]. Expenditure on food is recorded in a diary by a household member every day for the 2 weeks of the Household Budget Survey. Psychologically a person has little incentive to conceal the expenditure on food from fear of being accused of tax evasion.

Concerning the second assumption, the discussion in the previous section is taken into account, and thus the reporting of income by those in the public sector is assumed to be accurate. Accordingly, if Y_i is the true income of the household i and Y'_i is the income reported to the interviewer (recorded in the survey diary), then for employees in the public sector a true income is the same as reported income: $Y'_i = Y_i$, whereas for the self-employed and employees in private sector:

$$Y_i = k_i Y_i^{'}, \text{ where } k \geq 1 \qquad (1)$$

At this stage, contrary to the original model, it is assumed that there is a uniform technology of income underreporting by the self-employed and those employed in the private sector, which implies that $\boldsymbol{k}$ is not a random variable.

Relying on the presumption that there is a particular group of households in the population of interest that report their food expenditure as well as income level correctly, one can estimate a food consumption function for this group also taking into account a number of household characteristics. By inverting the estimated consumption function and applying it to the income underreporting group, the level of this group's actual income can be estimated. Introducing explanatory variables, the consumption function on item j could be estimated as follows:

$$\ln C_{ij} = Z_i \alpha_j + \beta_j \ln Y_i^{'} + \varepsilon_{ij} \qquad (2)$$

[1] Family Expenditure Survey data received from the CSB of Latvia is used. More explicit information on this is provided in the "Data" section of the paper.

Here, C_{ij} indicates the expenditure of household i on item j; Z_i is a vector of household characteristics, which are assumed to be correctly reported by all groups; α_j is a vector of parameters; β_j is a "marginal propensity to consume" an item j; and ε_{ij} is white noise. $Y_i^{'}$ is a measure of income that influences household consumption decisions. In this simplified model it is assumed that decisions related to food consumption are taken based on the current level of income.

To summarize, the following assumptions underly the simplified model:

- Expenditure on food is correctly reported by everybody.
- Income level is accurately reported by public sector representatives.
- The technology of income underreporting is uniform (k is not random).
- Food consumption decisions are based on current level of actual income.

As already discussed above, the actual income is equivalent to the reported income for employees in the public sector. The relation between the actual and reported income for the self-employed and those employed in the private sector is described by equation (1). This implies that if reported income is used instead of actual income in equation (2), then an additional regressor, lnk_i with a coefficient β enters it:

$$\ln C_{ij} = Z_i\alpha_j + \beta_j \ln Y_i^{'} + \beta_j \ln k_i + \varepsilon_{ij} \quad (3)$$

Estimation of eq. (3) for employees in the public sector and employees in the private sector separately would yield different intercepts due to the underreporting coefficient in the equation for private sector employees. The differences in the estimates could aid in estimating the extent of underreporting. Thus, the regression of the following form is ultimately run:

$$\ln C_{ij} = Z_i\alpha_j + \beta_j \ln Y_i^{'} + \gamma_j PR_i + \eta_i \quad (4)$$

Taking into account that the dummy coefficient is the difference between the private sector and public sector population means of $\ln C_{ij}$, from equations (3) and (4) the discrepancy can be expressed as:

$$\gamma_j = \beta_j \ln k_i \quad (5)$$

Consequently,

$$\ln k_i = \gamma_j / \beta_j \quad (6)$$

From this an estimate of the extent of underreporting can be obtained by inserting the estimated values from eq. (4) and taking an antilog of lnk_i.

3.2.2. Introducing Permanent Income

In reality, it is not the current level of actual income but rather permanent income that affects the food consumption decisions of households. Keeping the background of the problem of underreporting the same, further elaboration on the model described in the previous section is made and the issue of permanent income is introduced.

Thus, the working assumptions at the current stage of model development are as below:

- The expenditure on food is corretly reported by everybody.
- Income level is accurately reported by public sector representatives.
- The technology of income underreporting is uniform (k is not random).
- Food consumption decisions are based on permanent income level.
- The variation of actual income from permanent income is the same for private and public sector employees;
- p_i is a random variable ($\ln p_i \sim N(\mu_p ; \sigma_u^2)$).

Accordingly, the food consumption function (2) has to be adjusted to incorporate the permanent income idea and as a result to look as follows:

$$\ln C_{ij} = Z_i \alpha_j + \beta_j \ln Y_i^P + \varepsilon_{ij} \quad (7)$$

Here Y_i^P , a measure of income that influences household consumption decisions, is supposed to be less volatile than the observed income, Y'_i , for expenditure on such items as food. In the original methodology, the former is defined as "permanent income", without requiring that the expenditure function should conform to the permanent income hypothesis[2]. This presumption is held here as well.

The relation between permanent income and actual income can be depicted as:

$$Y_i = p_i Y_i^P \quad (8)$$

Here p_i is assumed to be a random variable, the expected value of which for every household depends on random events. Generally, the expected value of p_i will be above 1 in a so-called "good" year and it will have a mean value below 1 in a "bad" year. Here, the critical assumption is made that the mean of p_i as well as its variance are the same both for the employees in public and in private sector.

[2] Generally, PIH claims that people try to maintain a fairly constant standard of living throughout their lifetime, even though their income may vary considerably (Schenk, 2002).

Since no information on the levels of permanent income for running the regression (7) is available for households in the private and public sectors, instead the observed income is used and the regression of the form (4) will be run. However, in this case the income is treated as endogenous and instrumented and in order to obtain an independent estimate of the variance of errors in income, a reduced form income regression of the following type is run (*see* Appendix 2 for more detail):

$$\ln Y_i^{'} = Z_i\delta_i + X_i\delta_2 + \zeta_i \qquad (9)$$

where X_i is a set of identifying instruments (additional variables that could explain the level of income); ζ_i - a residual term, which consists of the three types of errors: unexplained variations in permanent income, deviations of actual from permanent income, u_i, which by assumption is the same for private and public sector employees, and deviations of actual income from reported income, v_i. Due to the latter, the residual variance of income of the privately employed is expected to exceed the residual variance of income of the publicly employed.

Due to the assumptions that $\boldsymbol{k_i}$ is not random and that there is no difference in variation of actual income from permanent income for the self-employed, private sector employees and public sector employees, the general formula for mean income underreporting could be derived from (5) and, in fact, it is of the same form as (6). The estimate for underreporting is not expected to be the same as that obtained using the simple model, provided the obtained estimates for β_j and γ_j are different.

3.2.3. Introducing Randomness of the Underreporting Coefficient

So far, the technology of tax evasion has been assumed to be homogeneous for underreporting households. This, however, might not hold in real life. The underreporting households may have various approaches towards doing this. Thus, at this final stage, the coefficient of underreporting, k_i, is assumed to be a random variable. Keeping other assumptions presented in previous sections, and introducing considerations about the possibility of a correlation between the variation of true income from the permanent one, and the variation of true income from the one that is reported, the authors further elaborate on the initial simple model.

The working assumptions at the last stage of model development are as below:

- Expenditure on food is corretly reported by everybody.
- Income level is accurately reported by public sector representatives.
- Food consumption decisions are based on permanent income level.
- The variation of actual income from permanent income is the same for private and public sector employees.
- p_i is a random variable $(lnp_i \sim N(\mu_p ; \sigma_u^2))$.
- The technology of income underreporting is heterogeneous, i.e. k_i is a random variable $(lnk_i \sim N(\mu_k ; \sigma_v^2))$.

With the purpose of estimating the food consumption function, the earlier presented regression of the form (4) should be run in which income is again treated as endogenous and instrumented due to the permanent income assumption. The independent estimate of income variance obtained from the reduced form income regression (9), as before, consists of three types of errors: unexplained variations in permanent income, deviations of actual from permanent income, u_i, which by assumption is the same for private and public sector employed, and deviations of actual income from reported income, v_i .

Taking into account the assumptions that k_i is a random variable and log-normal, the general formula for estimating the extent of income underreporting by self-employed and employees in the private sector has to be adjusted upwards (*see* Appendix 3 for more detail):

$$\ln \bar{k} = \gamma_j / \beta_j + \frac{1}{2}\sigma_{vPR}^2 \qquad (10)$$

Since there is no directly available estimate for the variance term in (10), estimation of underreporting is done using the difference in error variances for private sector and public sector employees from running the reduced form income regression (9).

Here a note on possible correlation between the variance of reported income from the actual (v_i) and the variance of actual income from the permanent (u_i) has to be made. Zero covariance would imply that whatever the level of received income the household would always tend to report a certain percentage of it. In this case the general formula for estimating the extent of underreporting would be:

$$\ln \bar{k} = \gamma_j / \beta_j + \frac{1}{2}(\sigma_{\zeta PR}^2 - \sigma_{\zeta PU}^2) \qquad (11)$$

However, it might also be true in reality that households try to avoid large fluctuations in their reported income and, therefore, try to smooth it out. This would mean that in a "good" year the household would report a smaller percentage of their income, which suggests a larger extent of underreporting in such years. By contrast, in a "bad" year, when the income level is lower than usual, the household would report a bigger share of it and, thus, would underreport less. The above implies a positive covariance between u_i and v_i. If this is the case, then formula (11) has to be adjusted upwards to account for the positive covariance between u_i and v_i:

$$\ln \bar{k} = \gamma_j / \beta_j + \frac{1}{2}(\sigma^2_{\zeta PR} - \sigma^2_{\zeta PU}) + \mathrm{Cov}(uv) \qquad (12)$$

The issue gets quite complicated at this point, since in order to find the covariance between u_i and v_i for particular values of the partial correlation coefficient, ρ, one also needs to know $\sigma_{u\,PU}$ and $\sigma_{v\,PR}$.

In fact, the variance of actual income from the permanent for the self-employed and for employees in the private sector can not exceed $\sigma^2_{\zeta PU}$, which is the total variation in income for public sector employees consisting of the residual variance in permanent income and variation of actual income from permanent one. Taking into consideration the preceding argument and the assumption that variation of permanent income from actual income is the same for both public and private sector employees, i.e. $\sigma_{u\,PU} = \sigma_{u\,PR}$, an estimate for $\sigma_{u\,PU}$, which is $\sigma_{\zeta PU}$, is available from the results obtained running the reduced form income regression (9). The difference in independent estimates of error variances from the reduced form income regression can be further expanded:

$$\sigma^2_{\zeta PR} - \sigma^2_{\zeta PU} = \sigma^2_{vPR} - 2\rho\sigma_{\zeta PU}\sigma_{vPR} \qquad (13)$$

The equation (13) can be solved for σ_{vPR} and - by inserting various values for the partial correlation coefficient - the coefficient of underreporting adjusted for covariance between u_i and v_i can be found from (12).

The three sections above have dealt with the development of a model for estimating the extent of underreporting by the self-employed and employees in the private sector by showing a gradual transition from a simple to a more advanced one. After the data set and

variables are described and the problems related to limitations of data set discussed, the empirical results for all the three models are presented.

3.3. Data

The data set used in the research is obtained from the Household Budget Survey, which is carried out monthly by the Central Statistical Bureau in Latvia. Every randomly selected household that has expressed their agreement to contribute to the research participates in the survey for 4 weeks. The survey includes carrying out two interviews in a household during which general information about the household is acquired. Additionally, it is required for the participating household members to provide daily expenditure information on various items for the whole period of the survey. The interesting feature of the survey is that the delicate questions, such as the ones related to income of the household, are asked in the very end of the survey during the concluding interview, when certain trust is established between the CSB representatives and the household members. This is believed to minimize the possibility of the household providing untrue information about themselves, especially on their income levels.

The information on a sample of households taking part in surveys conducted over 12 months in year 2003 is used in the paper. The year 2003 is chosen purposefully since it provides the latest data available that may provide a complete annual data set. The year 2004 was considered to be not convenient in the sense that it might incorporate certain expectations of price changes due to EU accession and, thus giving less accurate data on expenditure or income as in the preceding years.

3.4. Limitations to data accuracy and reliability

Due to the fact that the data obtained from the CSB of Latvia but not collected by the authors themselves is used in the paper, certain limitations and drawbacks to its accuracy and reliability as well as its implications for the estimation results have to be realized and accounted for.

First of all, the data quality may well suffer from the human factor resulting in omitted records, inconsistency in data, or similar problems. Therefore, those cases where obvious contradictions or inaccuracy in data were spotted were at once excluded from the sample. The main drawback that the household budget survey bears is that it can not be ensured that a participating household reports completely and fairly their expenditure on all items or on specific items that are of interest. Moreover, it is unfortunately impossible to check

correctness of data that might be impaired either due to human error as mentioned above or inaccurate reporting by households. This may result in an estimate that does not accurately reflect the true situation in the country.

Discrepancies in the structure of household surveys performed in Latvia and in the UK did not allow perfect replication of the original method mainly in terms of developing variables for food consumption and reduced form income regressions. The authors wish they could obtain more information about the household characteristics or other members of households apart from the main breadwinner. Some information, such as the level of education, part-time or full-time employment, age or various other characteristics of other members of households was not available. This limitation could be, firstly, attributed to the structure of the database, which did not allow compiling this information to create necessary variables. Secondly, the restrictions are due to the fact that the survey does not cover particular aspects of households. The availability of more detailed information on households and household members would presumably improve the precision of the estimates.

3.5. Sample and Variables

As already described in the section on methodology, the underreporting estimation procedure consists of two stages requiring running a regression for food consumption and a reduced form regression for income. For these purposes, from the data obtained in the survey two sets of variables were created, more detailed lists of which are presented in Appendix 4. The first set of variables represents a vector of household characteristics that are believed to determine the amount of food consumption by a particular household. The second set consists of variables that explain the income level and thus are helpful in estimating the wealth of a particular household.

In their work Pissarides and Weber, while constructing a number of variables, to a large extent rely on characteristics of the head of household - not necessarily being the main breadwinner - who is assumed to have a significant impact on expenditure decisions. Taking into account that the head of household is named by an interviewee and that the determination of the head of household at that particular moment may be affected, for example, by such factor as presence of wife/husband, identification of the head of household may be fairly subjective and not true. Therefore, in contrast to Pissarides and Weber, the authors created some variables representing household characteristics, for instance, age, education level or interacting variables for the private sector, based on information associated with the main breadwinner.

The sample of households used in the research is comprised of those consisting of two or more adults with or without children and where the occupation of the main breadwinner during the last 12 months may be associated with one of the following categories of social groups specified in the survey questionnaire: "employee (paid worker)", "employer", "self-employed", "employed in a family business". Households in which the occupation of the main breadwinner is related to agricultural activities or farming were excluded. This was done due to the fact that food expenditure function of such households may differ from that of the others, as they are expected to produce a considerable part of food themselves. Belonging of household members to either public or private sector can be straightforwardly identified only for those people who can be characterized as "employees (paid workers)", since such information is not available for the other three categories of social groups of interest. Therefore, those belonging to the groups of "self-employed", "employers" or "employed in a family business" were also assumed to be associated with the private sector, not the public.

The division of households into "private sector households" and "public sector households" was done rather arbitrarily according to the percentage of income coming from the respective sector. So, if at least 60 percent of total household income was obtained from employment in the private sector, then such household was considered to be a "private sector household". The dummy variable for such households took a value equal to one.

As a result of the above adjustments, a sample of 1702 households was obtained, which was the largest sample possible to obtain containing appropriate characteristics.

The authors also experimented with other groups of households, such as those consisting of one person with or without children or two-adult households with or without children, in which both adults fell into the category of "employees". No evidence on difference in food expenditure between private sector and public sector households or income underreporting was found within such groups (*see* Appendix 5 for estimates obtained for these groups). An underlying reason for these results might well be the small size of such samples. The authors then attempted to extend the sample size to include other types of households. As a result, the above-mentioned sample of 1702 households was constructed that was further used in the estimation process.

4. An Estimate of the Shadow Economy

This section of the paper deals with estimation of income underreporting by private sector employees and the self-employed in Latvia. The estimation process is carried out taking the same steps as described in the methodology part, i.e. proceeding from the simple model to a more advanced one, while presenting the results obtained using each of them.

4.1. Simple Model

The simple model of the expenditure-based method developed herein entails regressing the amount of food expenditure of households on a number of household characteristics and reported income (*refer to* Appendix 1 for the list of variables used in the estimation procedure). Before discussion of the results obtained from this regression, some descriptive statistics on some characteristics of the sample of the researched households are presented in the table below:

	Private sector	***Public sector***
Number of observations	367	1265
Household size	3.24 (1.015)	3.33 (1.031)
Ln(food expenditure)	6.8214 (0.5432)	6.8294 (0.5471)
Ln(income)	7.5358 (0.7466)	7.6908 (0.6659)

Table 2. *Some descriptive statistics on the sample of households (after controlling for influential observations). Note: the numbers in parantheses are standard deviations.*

As can be seen from Table 2, at first glance there do not seem to be any remarkable differences between private and public sector households. Some of the characteristics, though, are worth highlighting. Firstly, private sector and public sector households seem to be quite similar in terms of the number of people comprising them. Secondly, it looks like income is slightly higher for public sector households. At the same time, both groups of households tend to have a similar level of expenditure on food, which points out the possibility of underreporting by private sector households. Thirdly, the interesting fact is that, although income levels are quite similar for the two groups, standard deviation of income is higher for private sector households.

Within the framework of the simple model, food consumption regression of the form (4), once more presented below, was run in order to obtain an estimate of the extent of underreporting by the self-employed and private sector employees:

$$\ln C_{ij} = Z_i \alpha_j + \beta_j \ln Y_i^{'} + \gamma_j PR_i + \eta_i . \qquad (4)$$

The estimates of immediate interest are presented in Table 3 below, whereas detailed information on other coefficients is provided in Appendix 7 of the paper:

Variable	*Coefficient*	*Robust St. Error*	*t-statistics*
Ln (income)	0.3065394	0.0227796	13.46
Dummy PR	0.0656831	0.0271258	2.42

Table 3. *Some results obtained from food consumption regression estimation using the simple model.*

As expected, the coefficient before the logarithm of income is positive and significant. The coefficient of dummy variable for private sector households is also positive and significant, which constitutes a difference in intercepts between the two groups and indicates that the households characterized as belonging to the private sector tend to have higher expenditure on food controlling for a number of household characteristics.

From the estimates presented in Table 3 above, the coefficient of underreporting can be calculated using the earlier derived general formula (6). Accordingly, the simple model provides an estimate of underreporting being $\bar{k} = 1.23896$.

4.2. Introducing Permanent Income

As already discussed in the methodology section, it is not necessarily the current income level that influences food consumption decisions of households, but it may rather be permanent income instead. In order to incorporate the assumption on permanent income, while running the food consumption regression of the form (4), income was treated as endogenous and instrumented. The complete results from estimating the food consumption regression are available in Appendix 8. Below, the estimates required for calculating the extent of underreporting within the framework of this model are presented:

Variable	*Coefficient*	*Robust St. Error*	*t-statistics*
Ln (income)	0.4267184	0.030546	13.97
Dummy PR	0.0760742	0.027457	2.77

Table 4. *Some results obtained from food consumption regression estimation using the model with permanent income assumption.*

The coefficient of logarithm of income is positive and significant. The same holds for the coefficient before the dummy variable. The difference in coefficients of income of private and public sector households was tested by introducing income interactively with the private sector dummy. The t-statistic for the interactive term was -1.40, thereby showing the insignificance of the variable.

The general formula for calculating the extent of underreporting by private sector remains the same as in the simple model, being:

$$\ln k_i = \gamma_j / \beta_j \quad (6)$$

Using the estimates produced by running food consumption regression, the coefficient of underreporting is computed. Employing the model with the permanent income hypothesis, the authors obtain an estimate of the extent of underreporting equal to $\bar{k} = 1.1952$. This is, however, not the final stage of the estimation process since there remains one more assumption to be loosened, which implies uniform technology of income underreporting. As this presumption may well not hold in real life, the authors proceed with the next stage of elaboration of the model and introduce the notion of randomness of the coefficient of underreporting.

4.3. Introducing Randomness of Underreporting Coefficient

Should there be assumed heterogeneous technology of income underreporting among the self-employed and private sector employees, the general formula for calculating the extent of underreporting is no longer the same as in the previous stage since the estimate of underreporting has to be adjusted upwards. As before, the food consumption regression of the form (4) was run and, under the permanent income hypothesis, income was again treated as endogenous and instrumented. The latter enabled obtaining of independent estimates of residual income variances for both groups of households, which are needed for calculation of the income underreporting coefficient. According to the assumption maintained in the methodology part of the paper, the residual income variance is larger for private sector households. The estimates obtained from running the reduced form income regression provided in Table 5 conform to this assumption.

Variable	Private sector	Public sector
Standard deviation	0.6217036	0.6023766
Variance	0.3865	0.3628

Table 5. *Residual income standard deviation and variance for private and public sector households. Estimates obtained from running the reduced form income regression for private and public sector households separately.*

At this stage, assuming covariance between the variation of actual income from that reported and the variation of actual income from the permanent being zero for private sector households, the general formula of the following form is applied in order to find the coefficient of interest:

$$\ln \bar{k} = \gamma_j / \beta_j + \frac{1}{2}(\sigma^2_{\zeta PR} - \sigma^2_{\zeta PU})$$

The estimate of income underreporting obtained herein is: $\bar{k}$ = 1.2094. The upward adjustment of the previously obtained estimate was not very significant since the difference in residual income variances was not large between the two groups of households.

Considering a possible situation when underreporting households prefer to have a smooth pattern of income they report to the authorities, it may be alleged that covariance between the variation of actual income from reported income and the variation of actual income from the permanent one is no longer zero, but positive. Accordingly, the appropriate general formula for calculating the extent of underreporting by those households is:

$$\ln \bar{k} = \gamma / \beta + \frac{1}{2}(\sigma^2_{\zeta PR} - \sigma^2_{\zeta PU}) + \mathrm{Cov}(uv) \qquad (12)$$

In order to proceed with calculations, the covariance corresponding to different values of the partial correlation coefficient has to be found. For this purpose equation (13) is used:

$$\sigma^2_{\zeta PR} - \sigma^2_{\zeta PU} = \sigma^2_{vPR} - 2\rho\sigma_{\zeta PU}\sigma_{vPR} \qquad (13)$$

Since the true value of the partial correlation coefficient is not known, the authors can merely speculate on this issue. Thus, not a single figure but a range of possible estimates for income underreporting is computed. To perform this, several values of partial correlation coefficient are inserted into (13), which is then solved for σ_{vPR} using the estimates obtained from running the food consumtion regression (*see* Appendix 8).

For ρ = 0.3 (13) and (12) imply that $\bar{k}$ = 1.406621. For ρ = 0.5, the coefficient of income underreporting is equal to 1.777. And finally, if ρ = 0.7, (12) and (13) produce a rather high estimate of income underreporting, being = 2.519. The average of the three estimates is $\bar{k}$ =1.90087.

To summarize, the final estimate obtained, $\bar{k}$ =1.90087, shows by how much the group of households characterized here as belonging to the private sector underreports the amount of wages and salaries they obtain from self-employment and employment in the private sector. Looking at GDP from the income perspective, CSB of Latvia estimated that in 2003 wages and salaries comprised around 32.93 percent of total GDP in Latvia (*see* Appendix 9). Moreover, the fraction of wages and salaries coming from self-employment and employment in the private sector was around 70 percent in total for both sectors in 2003. Accordingly, the

calculated coefficient of income underreporting can be now translated into the final estimate of the shadow economy in Latvia, being approximately 20.766 percent of GDP in year 2003.

5. Concluding Remarks

As a result of the estimation work performed by the authors and described in the paper it was found that the food expenditure of the private sector is indeed higher than that of the public sector, controlling for factors determining the income level and food consumption of households. The coefficient of income underreporting produced is around 1.901. This implies the size of the shadow economy in the form of tax evasion in Latvia equal to about 21 percent of GDP in 2003. The result is comparable to the some other estimates obtained in other researches (*refer to* Table 1 above). On the one hand, it may be the case that the earlier applied methods and the expenditure-based approach capture the same aspects of the shadow economy in Latvia and, hence, lead to analogous results. However, it is a possibility that the 21 percent obtained does not characterize the size of the total shadow economy in Latvia. The reason for this may be that the expenditure-based approach applied, which is mainly oriented on the tax evasion problem, does not capture other possible aspects of the shadow economy to the full extent. This means that the actual size of the shadow economy in Latvia might well be significantly larger.

As already mentioned before, there is a substantial discrepancy among the estimates of the size of the shadow economy in Latvia depending on the methodology applied and timing of researches. Apart from the estimates earlier presented, one of the recent ones referred to by the Latvian weekly journal "Telegraf" is the size of the shadow economy in Latvia being 41.3 percent of GDP in 2002 – 2003, the estimate being obtained by Friedrich Schneider. The same source reports that shadow activities in Estonia amount to 40.1 percent of GDP for the same period. The situation in Lithuania is somewhat better; there, the size of the shadow economy is estimated to be around 32.6 percent of GDP (Baltic International Bank, 2005). With the estimated size of the shadow economy, according to the journal, "Latvia is now a clear front-runner among EU countries. Similar figures are seen among countries in Africa, and Central and South America - this region has been traditionally prone to shadow economic activities".

It is worth pointing out that the size of the shadow economy estimated at a level of 21 percent in this paper should be of concern to the government. This indicates that much tax income is foregone in the country that could be used for further development and

enhancement of its social security system, infrastructures, to give but two example. Another consequence of such a considerable size of the shadow economy is that there is a clear distortion in the competitive situation in the market.

In order to improve the current situation, first of all the roots of the problem must be tackled. Numerous reasons can be stated for tax evasion and shadow activities in the country. However, according to Trasberg the typical priorities for policy considerations in transition countries are as follows. One of the primary causes of shadow activities in the country is the excessive tax burden on individual and businesses, which encourages informal activities and discourages formal employment. Another important reason is considered to be the high level of regulation, bureaucracy, and corruption, which were a consequence of the uncertain legal environment and lack of democratic control over institutions in newly independent countries. The last but not least lay in the social aspect of the country. The general tax collection system should be designed to increase individuals' loyalty and compliance with their tax liabilities. For this to work, there is a need to encourage tax "ethics" and social norms that would be accepted and recognized by society. Although the Latvian government has already taken certain action to deal with the above problems, the result is still unsatisfactory in light of the high estimates characterizing the amount of shadow activities in the country, including that obtained as a result of the current research.

Taking into account the contradictory nature of information on Latvia's shadow economy and persisting differences between estimates produced by local and foreign researchers applying various methods, a proposition is made on the usefulness of research dealing with application of the expenditure-based method for other periods in Latvia. This would enable a more comprehensive and conclusive comparison of the methods and the estimates they produce. This would also assist in tracking the dynamics of development of the informal economy in the country.

Accounting for the threat to validity of the findings that the quota sampling is suspected to cause, the suggestion is made to avoid this sampling technique. An intermediate solution can be to revisit the households that initially declined the offer to participate in the survey. And then check for correlation of instances with the amount of food expenditure of such households. As discussed in the previous section, this is believed to help find the true extent of income underreporting in Latvia and see whether the current research indeed produces an underestimated result.

This initial research on the application of the expenditure-based method in Latvia can be further developed and enriched should there be more extensive data available on other

household characteristics and other household members. Since the method implies using rather detailed information on households, including various data on employment of household members, it could be further applied to estimate the extent of income underreporting by those employed in particular industries in Latvia.

All in all, the paper constitutes a look taken from a new angle at the problem of the shadow economy in Latvia. Having carried out the current research, the authors have made an original contribution to society by tackling the problem of indirect measurement of informal economic activity in the country, in using a new approach and by showing the extent of necessary adjustment of GDP as calculated from the income perspective.

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Appendices

Appendix 1

Model of Tax Evasion

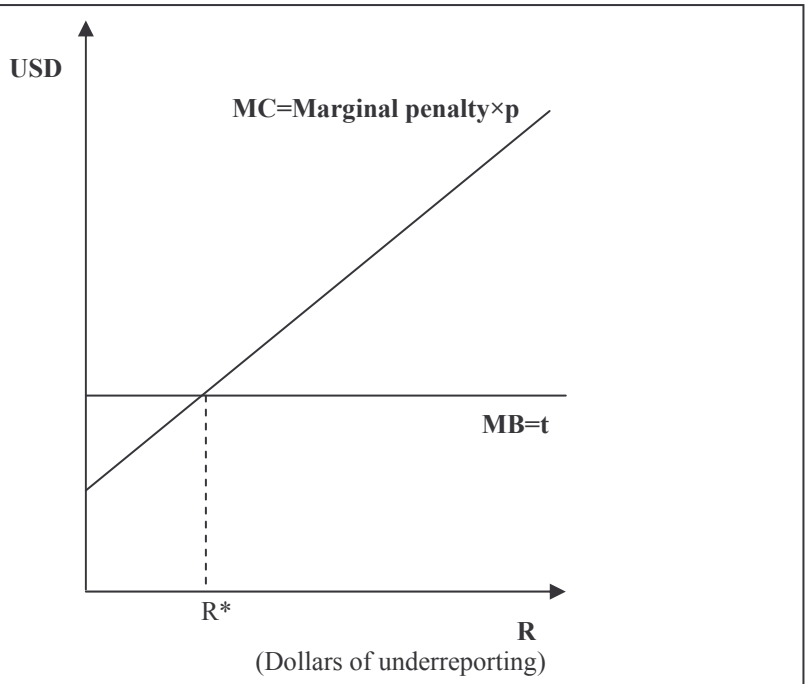

Figure 1. *Graphical representation of tax evasion.*
Source: Rosen, Harvey S. Public Finance. Singapore: McGraw-Hill, 1999.

Appendix 2

Model with Assumption on Permanent Income: Derivation

Underlying assumptions for deriving a simple expenditure-based method with an additional assumption about permanent income are already given in the body text, hence they will not be repeated here unless crucially needed.

The difference between the simplified and one-assumption-added models is that in addition to the variable k_i , new variable p_i is introduced, which incorporates the difference between the permanent and actual income. Thus, the following two equations describing the interrelation between the reported and actual income are obtained:

$$Y_i = p_i Y_i^P \qquad \text{and} \qquad Y_i = k_i Y_i^{'}$$

By taking logs (to simplify the calculations) and equalizing the right-hand sides of the two equations, the following interrelation between the permanent and reported incomes is obtained:

$$\ln Y_i^P = \ln Y_i^{'} - \ln p_i + \ln k_i$$

Since the level of the permanent income is an unknown variable in the equation (7) in the text, the above relation is used and the permanent income in the consumption function (7) is replaced by the values on the right-hand side of the equation written here. Thus, the consumption function should look as follows:

$$\ln C_{ij} = Z_i \alpha_j + \beta_j \ln Y_i^{'} - \beta_j \ln p_i + \beta_j \ln k_i + \varepsilon_{ij}$$

In the original consumption function two additional regressors are introduced (lnp_i and lnk_i), on which there is no data available (note that the primary goal of the paper is to estimate k_i). To make the calculations possible, some inferences on the variables should be made. At this stage of the method, the variable k_i is assumed to be non-random, thus no additional information on its log could be presented. However, as p_i is assumed to be a random and log-normal variable, thus its log could be expressed as the deviation from its mean:

$$\ln p_i = \mu_p + u_i$$

Since $\ln p_i \sim N(\mu_p; \sigma_u^2)$, then

$$E(p_i) = e^{\mu_p + 1/2\sigma_u^2}$$

$$\ln(E(p_i)) = \mu_p + 1/2\sigma_u^2$$

The random variable u_i has a zero mean and a constant variance for the privately and publicly employed (i.e. $\sigma_{uPR}^2 = \sigma_{uPU}^2$). Additionally, by the log-normality of p_i, the following interrelation between the mean of p_i and the mean of its log could be observed:

Thus, by incorporating the features of lnp_i into the consumption function, ultimately it looks like:

$$\ln C_{ij} = Z_i \alpha_j + \beta_j \ln Y_i^{'} + \beta_j \ln k_i - \beta_j \mu_p - \beta_j u_i + \varepsilon_{ij}$$

As the goal of the paper is to estimate the size of the mean of underreporting by the privately employed holding that publicly employed report their income correctly (i.e. to get the numerical value of the coefficient *k*), it could be calculated only by getting the difference between the variance of the errors from the consumption function for each occupational group. Thus, the consumption functions for each group separately are as shown below:

Privately employed: $\ln C_{ij} = Z_i\alpha_j + \beta_j \ln Y_i^{'} + \beta_j \ln k_i - \beta_j \mu_{pPR} - \beta_j u_i + \varepsilon_{ij}$

Publicly employed: $\ln C_{ij} = Z_i\alpha_j + \beta_j \ln Y_i^{'} + \beta_j \ln k_i - \beta_j \mu_{pPU} - \beta_j u_i + \varepsilon_{ij}$

Therefore, by denoting the difference between the two functions above as γ_j (which is a coefficient of the dummy variable introduced to the consumption function to estimate the consumption pattern for the two different occupational groups), the value of *k* could be obtained from the following function:

$$\gamma_j = -\beta_j(\mu_{pPR} - \ln k_i) + \beta_j \mu_{pPU} = -\beta_j \mu_{pPR} + \beta_j \mu_{pPU} + \beta_j \ln k_i =$$
$$= -\beta_j(\mu_{pPR} - \mu_{pPU}) + \beta_j \ln k_i$$

Here, the simplification on the size of $(\mu_{pPR} - \mu_{pPU})$ could be made by taking into consideration the assumption that p_i is the same for the privately and publicly employed, i.e.:

$$\mu_{pPR} + 1/2\sigma^2_{uPR} = \mu_{pPU} + 1/2\sigma^2_{uPU} \Leftrightarrow \mu_{pPR} - \mu_{pPU} = -1/2(\sigma^2_{uPR} - \sigma^2_{uPU}) \le 0$$

However, the authors also make an assumption that the variation of actual income from

$$\mu_{pPR} - \mu_{pPU} = -1/2(\sigma^2_{uPR} - \sigma^2_{uPU}) = 0$$

permanent one is the same for the publicly and privately employed, which means that volatility of income is the same for the both occupational groups. This implies that $\sigma^2_{uPR} = \sigma^2_{uPU}$, which also results in:

By plugging in the results of the last equation into the one that estimates γ_j, this simple equation for the calculation of *k* is received:

$$\gamma_j = \beta_j \ln k_i, and$$
$$\ln \bar{k} = \gamma_j / \beta_j$$

The values of γ_j and β_j are obtained by running the regression of the following form separately for the blue and white-collars (hence, the estimate of *k* is also received separately for these two groups):

$$\ln C_{ij} = Z_i\alpha_j + \beta_j \ln Y_i^{'} + \gamma_j PR_i + \eta_i$$

Here, one should note that the level of reported income should be treated with the caution due to introduction of the permanent income, which requires some additional adjustments. As already shown above:

$$\ln Y_i^P = \ln Y_i^{'} - \ln p_i + \ln k_i$$

The rearranged equation for reported income looks as follows:

$$\ln Y_i^{'} = \ln Y_i^P + (\ln p_i - \ln k_i) = \ln Y_i^P + (\mu_p + u_i - \ln k_i) = \ln Y_i^P + (\mu_p - \ln k_i) + u_i$$

It could be seen that the level of reported income is to a certain extent determined by permanent income. And since there is no data available on it, the approximation of this variable should be done by introducing additional instrumental variables that could explain the level of income of households. Therefore, additional income function is introduced here, which is used to estimate the level of income to be used in estimating consumption function:

$$\ln Y_i^{'} = Z_i\delta_1 + X_i\delta_2 + \zeta_i$$

Here, Z_i is the set of household characteristics (the same as in the consumption function) and X_i is a set of additional variables explaining the level of household income. Therefore as some additional variables explaining the level of income are added, the estimates of income and dummy variable coefficients should be different than the ones obtained from the simple model. Hence as the final derivation of the underreporting coefficient is the same in both models, the numerical estimates, nevertheless, should differ.

Appendix 3

Model with Random Coefficient of Underreporting: Derivation

Introduction of the randomness of the distribution of k_i and assumption of it being log-normal leads to the following relation between its log and mean:

$$\ln k_i = \mu_k + v_i$$

Therefore the relation of the permanent income and the reported income eventually acquires the following look:

$$\ln Y_i^P = \ln Y_i^{'} - (\mu_p - \mu_k) - (u_i - v_i)$$

In this case, the consumption function to be estimated also has to be adjusted to account for the randomness of k_i:

$$\ln C_{ij} = Z_i \alpha_j + \beta_j \ln Y_i^{'} - \beta_j (\mu_p - \mu_k) - \beta_j (u_i - v_i) + \varepsilon_{ij}$$

Here again, to estimate the coefficient k_i, the difference of the means of the privately employed and publicly employed should be taken, which is captured by γ_i. Therefore, to grasp the essence of the model better, the separate consumption functions for each occupational group will be presented and the difference taken to get the mathematical expression for calculating the coefficient of underreporting (k_i):

Privately employed: $\ln C_{ij} = Z_i \alpha_j + \beta_j \ln Y_i^{'} - \beta_j (\mu_{pPR} - \mu_{kPR}) - \beta_j (u_{PR} - v_{PR}) + \varepsilon_{ij}$

Publicly employed: $\ln C_{ij} = Z_i \alpha_j + \beta_j \ln Y_i^{'} - \beta_j (\mu_{pPU} - \mu_{kPU}) - \beta_j (u_{PU} - v_{PU}) + \varepsilon_{ij}$

Since it is assumed that the mean of p_i is the same for the privately and publicly employed, then $\mu_{pPR} = \mu_{pPU}$, which also gives that $u_{PR} = u_{PU}$ (as already shown in Appendix 2); and since $k = 0$ for the publicly employed, then $lnk_{PU} = 0$ and $\mu_{kPU} = 0, v_{PU} = 0$. For the sake of simplicity in the following equations μ_{kPR} is noted as μ_k. The equation for estimating k_i is:

$$\gamma_j = -\beta_j \mu_{pPR} + \beta_j \mu_k + \beta_j \mu_{pPU} + \beta_j v_{PR} = \beta_j (\mu_{pPU} - \mu_{pPR}) + \beta_j \mu_k \Leftrightarrow$$
$$\gamma_j = \beta_j \mu_k \Rightarrow \mu_k = \gamma_j / \beta_j$$

Therefore, by replacing the value of μ_k in the $\ln k_i = \mu_k + 1/2\sigma_v^2$ by the estimated coefficients from the consumption function, we get:

$$\ln \bar{k} = \mu_k + 1/2\sigma_v^2 = \gamma_j / \beta_j + 1/2\sigma_{vPR}^2$$

The values for γ_j and β_j are received from the estimated consumption function. In general, the variance of v_i (σ_{vPR}^2) is not known but the inference on it could be made from the estimated residual income variances. This could be done by applying the assumption already made, i.e., that the unexplained variations in permanent income are the same for both employees in the public and in the private sectors. Thus we get:

$$\sigma_{YPR}^2 - \sigma_{YPU}^2 = \text{var}(v-u)_{PR} - \text{var}(u)_{PU} = \sigma_{vPR}^2 + \sigma_{uPR}^2 - 2Cov(uv)_{PR} - \sigma_{uPU}^2$$
$$\sigma_{YPR}^2 - \sigma_{YPU}^2 = \sigma_{vPR}^2 + \sigma_{uPR}^2 - 2\rho\sigma_{uPR}\sigma_{vPR} - \sigma_{uPU}^2$$

Since $\sigma_{uPR}^2 = \sigma_{uPU}^2$ (according to the assumption made), then:

$$\sigma_{YPR}^2 - \sigma_{YPU}^2 = \sigma_{vPR}^2 - 2\rho\sigma_{uPR}\sigma_{vPR}$$

To be able to estimate σ_{vPR}^2 the only unknown estimate is the correlation coefficient. Thus only by assuming the size of this coefficient could the size of the underreporting coefficient be estimated, which is done in the methodology and the result estimation parts of the paper.

Appendix 4

List of Variables

lfood	= logarithm of total expenditure on food
hhsize	= number of persons in the household
AGE	= age of the head of household minus 30
AGESQ	= (age of the head of household – 30)^2
KIDS	= number of household members under 17 years old
KIDSSQ	= (number of household members under 17 years old)^2
EDU	= dummy variable for households with the main breadwinner with higher education
CITY	= dummy for households living in a city
RIGA	= dummy for households living in Riga
lfood_k	= logarithm of the amount of food obtained "in kind" (without being paid for), e.g. from relatives, grown by household, as social aid, etc.
lY_other	= logarithm of the amount of income other than salary (e.g. from property, from rent, transfers, etc)
lnY	= logarithm of the amount of total household income obtained from employment either in the public or private sector
PR	= dummy for private sector household in which at least 60 percent of income comes from the private sector
PRD	= dummy for household in which the main breadwinner is employed in the private sector

Table 1. *Household Characteristic Variables.*

WP1	= number of employed persons in the household
CAR1	= number of new cars owned by the household
CARN2	= number of second-hand cars owned by the household
ROOM	= number of rooms
DW	= dummy for ownership of a dishwasher
LAND	= dummy for ownership of land
VIDCAM	= dummy for ownership of a video camera
WM	= dummy for ownership of a washing machine
COMP	= dummy for ownership of a computer
MOB	= numbers of mobile phones owned by members of a household
SAT	= dummy for ownership of a satellite
INTER	= dummy for Internet connection

Table 2. *Instrumental Variables.*

Appendix 5

Results from Simple Model: Sample of Households with One Adult

Variable	Coefficient	(Robust St.Error)
lfood	-0.0208921	(0.0133196)
lnY	0.1561572**	(0.0617242)
lY_other	0.0167193	(0.0148094)
AGE	0.0193561***	(0.0059892)
AGESQ	-0.0003877**	(0.0001842)
EDU	0.0587308	(0.0665577)
CITY	0.0887613	(0.0803837)
RIGA	0.1908144***	(0.0673782)
KIDS	0.2876963***	(0.0612556)
PR	0.0390948	(0.0626933)
Constant	4.725047***	(0.4643654)
N	324	
R^2	0.2224	

Table 1. *Food consumption regression estimates for one-adult households.*
Note: Here PR, private sector dummy takes value equal to 1 if the adult is employed in private sector. Private sector dummy insignificant.

*** - significant at 1% significance level
** - significant at 5% significance level
* - significant at 10% significance level

Appendix 6

Results from Simple Model: Sample of Households with Two Adult "Employees"

Variable	Coefficient (Robust St. Error)
lfood_k	-0.0054974 (0.0090229)
lnY	0.4839833*** (0.0848282)
lY_other	0.016795 (0.0111671)
AGE	0.0194653*** (0.0056867)
AGESQ	-0.0001667 (0.0002053)
CITY	0.1242145** (0.0592023)
RIGA	0.0297793 (0.0603485)
KIDS	0.1166029*** (0.0335022)
PR	0.0479128 (0.0450583) (t-stat 1.06)
Constant	2.513691*** (0.6806763)
N	393
R^2	0.2467

Table 1. *Food consumption regression estimates for the sample of Two- person households.*
Note: Here the households the dummy for private sctor household takes value equal to 1 if at least 60% of total income for the household comes from the private sector. *Additional instruments* for income: CAR1, CAR2, FTH, and product of PRD with CAR1, CAR2, VIDCAM, INTER, AGESQ, AGE, KIDSSQ, KIDS, MOB, ROOM, DW, LAND, COMP, SAT.

*** - significant at 1% significance level
** - significant at 5% significance level
* - significant at 10% significance level

Appendix 7

Estimates from Simple Model

Variable	Coefficient (Robust St. Error)	t-statistics
lfood_k	-0.0160486 (0.0047535)	-3.38
lnY	0.3065394 (0.0227796)	13.46
lY_other	0.0231045 (0.0060701)	3.81
AGE	0.1668396 (0.1080684)	1.54
AGESQ	-0.0139337 (0.0305319)	-0.46
EDU	0.0385024 (0.0258338)	1.49
CITY	0.080491 (0.0317289)	2.54
RIGA	0.1507182 (0.0266742)	5.65
KIDS	-0.0609647 (0.0338302)	-1.80
KIDSSQ	0.0093711 (0.0067476)	1.39
WP1	0.0205201 (0.0220421)	0.93
hhsize	0.1326294 (0.0204393)	6.49
PR	0.0656831 (0.0271258)	2.42
Constant	3.624829 (0.1894746)	19.13
N	1632	
R^2	0.3127	

Table 1. *Food consumption regression estimates of the simple model.*

Appendix 8

Estimates from Model with Assumption on Permanent Income

Variable	Coefficient	(Robust St. Error)	t-statistics
lfood_k	-0.0152813	(0.004764)	-3.21
lnY	0.4267184	(0.030546)	13.97
lY_other	0.0296173	(0.0059013)	5.02
AGE	0.1230071	(0.0214918)	5.72
CITY	0.0685913	(0.0324376)	2.11
RIGA	0.11149	(0.0276768)	4.03
KIDS	-0.0826853	(0.0325414)	-2.54
KIDSSQ	0.0138788	(0.0069596)	1.99
hhsize	0.1265735	(0.0180088)	7.03
PR	0.0760742	(0.027457)	2.77
Constant	2.790427	(0.2349961)	11.87
N	1620		
R^2	0.3053		

Table 1. *Food consumption regression estimates after introducing permanent income.*
Note: Here the households the dummy for private sector household takes value equal to 1 if at least 60% of total income for the household comes from private sector. Income treated as endogenous and instrumented. *Additional instruments for income:* WP, EDU, AGESQ and the product of PRD with: CAR1, CAR2, VIDCAM, INTER, AGE, KIDSSQ, KIDS, MOB, ROOM, DW, LAND, COMP, SAT.

Appendix 9

Statistics used in calculating the GDP adjustment percentage: GDP Composition; Wages and Salaries by Sector

Component	Thsd LVL	Percent (of GDP)
Compensation of employees:	2 537 159	40.13%
out of which Wages and salaries	2 082 068	32.93%
Employers' social contributions	455 091	7.20%
Taxes on production and imports	724 576	11.46%
Subsidies (-)	53 460	0.85%
Operating surplus and mixed income, gross	3 114 208	49.26%
GDP	**6 322 483**	**100%**

Table 1. *GDP of Latvia by income approach (at current prices, year 2003).*
Source: Central Statistical Bureau. Macroeconomic Indicators of Latvia. Quarterly bulletin. Riga: Central statistical Bureau of Latvia, 2004.

Sector	Percent
Private	67.40%
Public	30.07%
Self-employed	2.53%
Total economy	**100%**

Table 2. *Distribution of income in the form of wages and salaries in Latvia according to the sectors of economy(2003). Source:* Central Statistical Bureau of Latvia, 2003.

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