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USING PERSONAL CAR REGISTER FOR MEASURING ECONOMIC INEQUALITY IN COUNTRIES WITH A LARGE SHARE OF SHADOW ECONOMY: EVIDENCE FOR LATVIA

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We suggest using information from the state register of personal cars as an alternative indicator of economic inequality in countries with a large share of shadow economy. We illustrate our approach using the Latvian pool of personal cars. Our main finding is that the extent of household economic inequality in Latvia is much larger than officially assumed. According to Eurostat, the officially published estimate of the Gini coefficient for Latvia is 0.374 for 2009, which is much higher than the Gini coefficient value reported for all the 27 EU member countries (0.304), but significantly lower than 0.48 according to our results.

JEL Codes: D31, E26, Z13

Keywords: cars, economic inequality, Gini coefficient, Latvia, social signaling

1. INTRODUCTION

You are what you drive.

Economic inequality among households is an important characteristic of the welfare of a country. Societies experiencing too high inequality might be subject to increased levels of criminality, drug and alcohol consumption, as well as political instability. Moreover, excessive inequality can have detrimental consequences for economic growth.[1] Governments pursue various redistributive policies in order to

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[1]Thorbecke and Charumilind (2002) provide an extensive review of the literature on inequality and its socio-economic impact.

lessen excessive inequality among households. However, reliable indicators are needed in order to evaluate the current stance of economic inequality as well as to monitor progress of such policies.

A typical way of how economic inequality is measured is by means of household budget surveys. The data are collected from a limited number of representative households, which are asked to fill in the questionnaires including various questions concerning their expenditure and income. While such a practice of data collection is widespread, there are a number of problematic issues: (1) only a limited number of households are selected (invited) to participate; (2) the participation is voluntary and verification of supplied information is costly and may not always be possible; (3) the voluntary surveys suffer from the so-called "middle-class bias" (Becker and Hauser, 2003) when households with very high and very low income levels typically are not sufficiently represented; and (4) Latvia is also characterized by a very high non-response rate of participation in surveys. For example, in the Household Budget Survey 2010 (HBS), the overall non-response rate was 56.9 percent; i.e., in numerical terms it means that for 5004 out of 8802 households selected in the HBS sample, the planned interviews were not carried out (Central Statistical Bureau of Latvia, 2012 table 5). It is also remarkable that in Riga and urban areas, where the incomes are generally higher than in rural areas, the non-response rates were 67.2 percent and 56.6 percent, respectively. In rural areas the recorded non-response rate was much lower, 40.2 percent.

In countries with a large share of underground economy, this type of data collection, that is largely based on voluntary participation, may be more problematic than in developed economies with a good functioning state. In the former countries, due to the fact that the lion's share of income is derived from unreported economic activity, the respondents may tend to underreport their true expenses/earned income in interviews or be less motivated to take part in these surveys. Hence, in those countries one would expect that the reported picture may be more distorted than that in countries with a higher income-reporting/tax-paying discipline.

In order to overcome such distortions, typically alternative and, sometimes, unconventional approaches are called for.[2] Our paper follows suit and proposes an alternative indicator of economic inequality among households based on information from a state register of personal cars. In contrast to surveys, where participation is voluntary and verification of provided responses is costly (if possible at all), the accuracy of information on possessed cars is easy to verify, and therefore it is not in the best interests of respondents to provide inaccurate or false statements.

Our suggestion is based on the perception that personal cars, because of their intrinsic characteristics, are not only a means of transportation but also an important device that can be and is widely used for signaling of social status and hence of economic well-being of their owners.[3] Thus, as noted in Clark (2009), car owners

[2]Economists are well known for the use of such alternative indicators (*The Economist*, 2011).

[3]Using residential data for the San Francisco Bay Area, Choo and Mokhtarian (2004) identify factors influencing the decisions of customers regarding which make and model to choose when they buy a car.

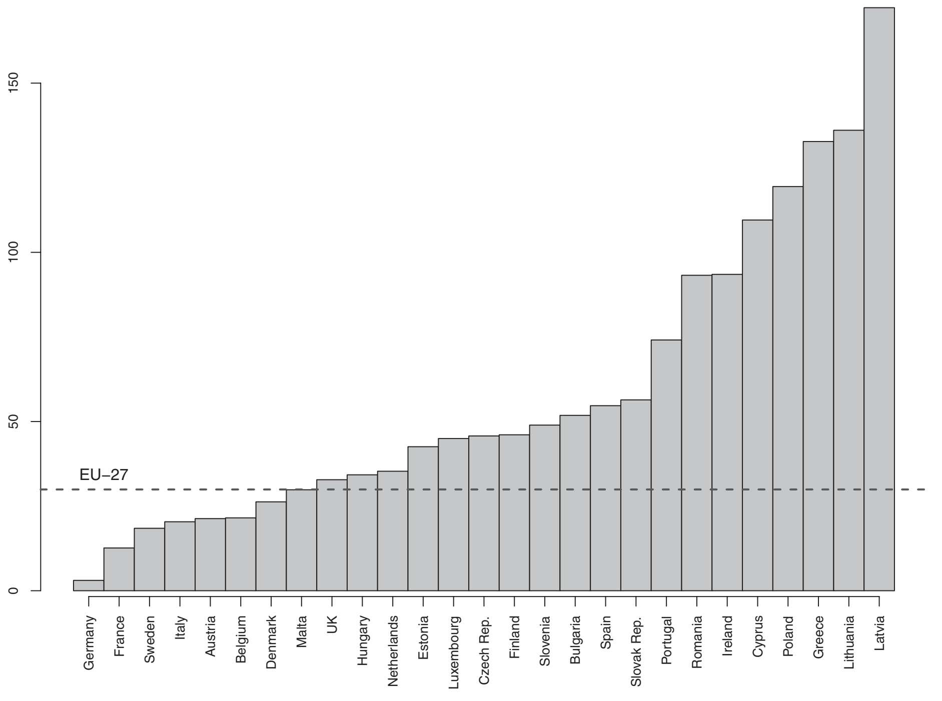

Figure 1. Growth of Car Stock between 1995 and 2009

Source: Eurostat (2011), EU Transport in Figures.

enjoy not only practical advantages of the increased mobility but also a number of intangible and nevertheless highly valuable social benefits. In this respect, cars distinguish themselves from other durable goods like washing machines and refrigerators that are kept behind closed doors and therefore are difficult to use to impress other people unless one invites them home. The bulk of the literature also suggests that car ownership increases at a similar or slightly larger rate with income (e.g., see Clark and Finley, 2010), signifying the fact that since their invention in the nineteenth century, automobiles still remain a very popular consumer good that people aspire to have.

The use of personal cars as a signaling device may be even more pronounced in countries of Eastern Europe, where until the breakdown of the Soviet Union, personal cars were one of the most desirable but often unattainable to common people consumer goods. Unsurprisingly, in the aftermath of the fall of the Soviet block, one of the first things that residents of the countries in question did was to satisfy their for a long time suppressed wishes to own a car. Data collected by Eurostat support this observation. Figure 1 displays growth in passenger car stock for each of the EU-27 counties during the period 1995–2009. In general, the Eastern European countries experienced very high growth rates compared to the old EU member states. The crave for cars in those post-communist countries is also clearly reflected in the fast growth of motorization (defined as a number of passenger cars per 1,000 inhabitants) during this period, as shown in Figure 2.

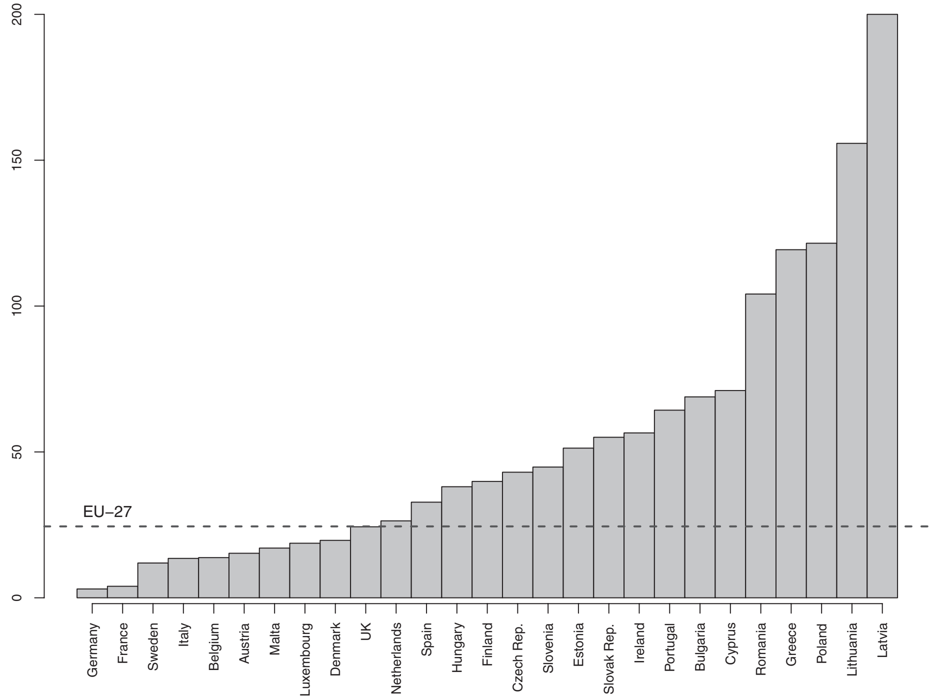

Figure 2. Growth in Motorization (defined as number of cars per 1,000 inhabitants) between 1995 and 2009, %

Source: Eurostat (2011), EU Transport in Figures.

Of course, such record growth rates in car ownership can be explained by the fact that the initial motorization degree was comparatively low in these countries in the mid-1990s, as shown in Figure 3.

We illustrate the use of information on registered cars for measuring economic inequality using Latvian data as an example. Our choice of Latvia is not purely accidental. Latvia is a small Eastern European country that regained its independence in 1991. Since independence Latvians were very active in acquiring personal cars. In fact, during the period between 1995 and 2009 the stock of personal cars in Latvia was growing at the fastest pace among the EU-27 countries, by far outpacing not only countries of Western Europe but also its peer post-communist countries (see Figure 1). In 2009, there were 510,000 registered personal cars—a slight drop from the peak level of 537,866 in 2007, as a result of the recent crisis.

Interestingly, during the period from 1995 until 2009, the total population in Latvia declined by about 9.8 percent from 2,469,531 in 1995 to 2,248,374 in 2009 (Central Statistical Bureau of Latvia).[4] Accordingly, there were 8,886,000 households in 2009 in Latvia, indicating that on average more than a half of households

[4]The results of the new census 2011 indicate that, as of March 1, 2011, there were 2,070,371 inhabitants in Latvia. This may suggest that estimates for 2009 are too optimistic.

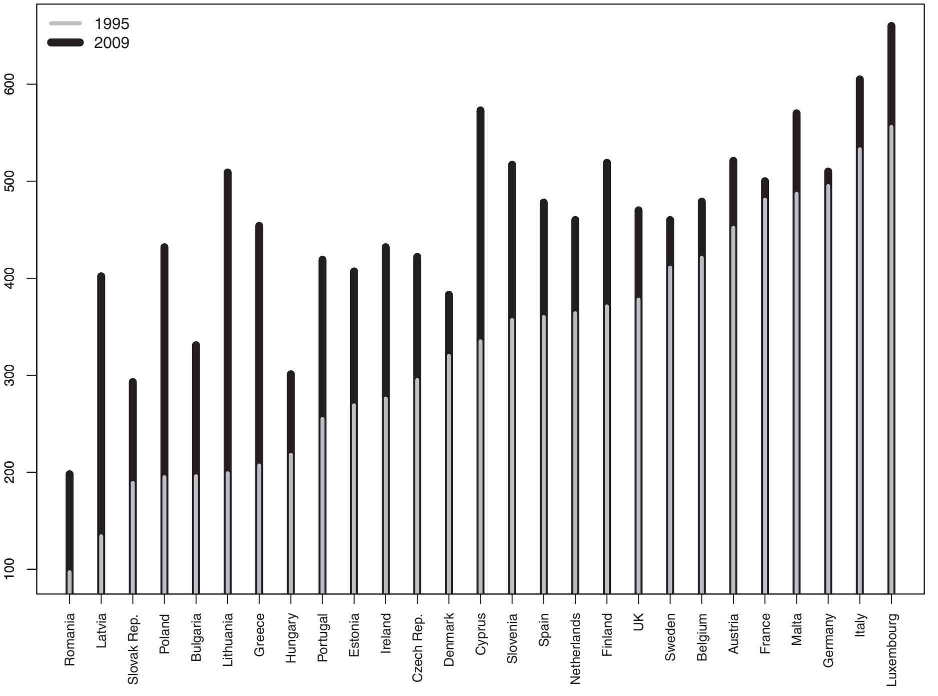

Figure 3. Degree of Motorization (number of cars per 1,000 inhabitants) in 1995 vs. 2009
Source: Eurostat (2011), EU Transport in Figures.

own an automobile. This also signifies that cars are a popular consumer good that is affordable for a wide range of Latvian residents with different incomes and tastes.

There are two more additional features of Latvia that make our suggestion to measure the income inequality using an alternative indicator-based approach particularly interesting. First, there is a substantial share of underground economy in Latvia. Schneider *et al*. (2010, table 3.3.3, p. 23) estimate that in the period 1999–2007 the average size of the shadow economy was 29.2 percent of the Latvian GDP. For comparison, the largest shares of shadow economy among 21 transition countries examined in the study are in Ukraine and Georgia and attain 49.7 percent and 65.8 percent, respectively. The lowest shares of the shadow economy are estimated in the Slovak Republic (18.1 percent) and Czech Republic (18.4 percent). In addition, because of devastating effects of the recent financial crisis—it is estimated that during 2008–09 the Latvian GDP cumulatively declined by about 25 percent—and the associated austerity packages implemented by the government (including a rise in VAT and other taxes), it is very likely that the share of underground activity in Latvia did not diminish but rather increased in the recent period.

The second interesting feature of the Latvian society is that among all EU-27 countries it was ranked at the top of officially measured income inequality, as illustrated in Figures 4 and 5. In Figure 4, the values of the Gini coefficients are

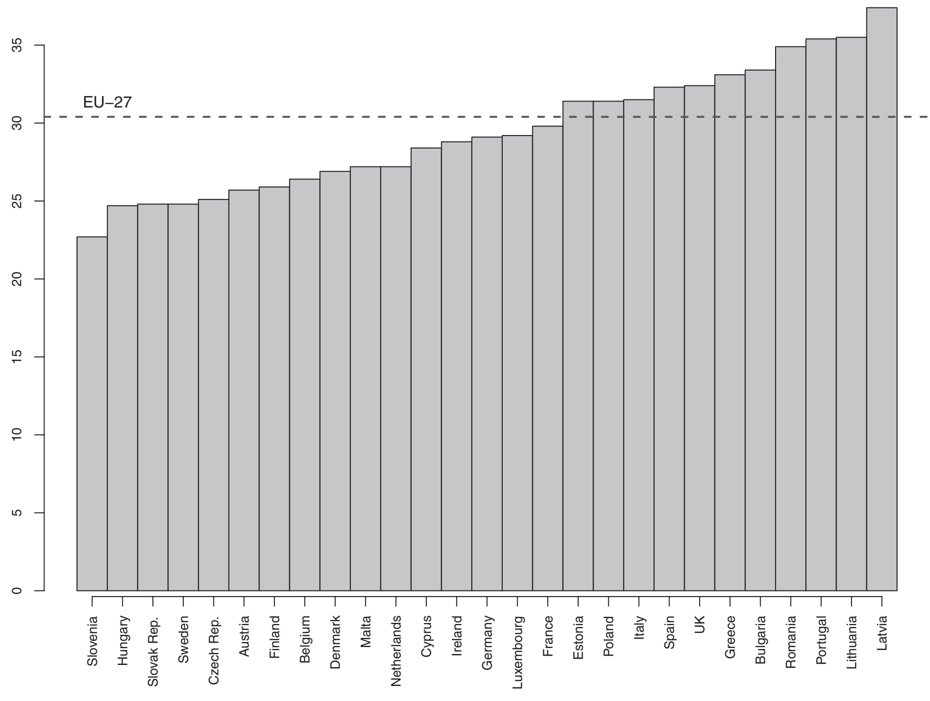

Figure 4. Income Inequality in the EU-27 Countries in 2009: Gini Coefficient
Source: Eurostat (2012), European Union Statistics on Income and Living Conditions (EU-SILC).

reported. In Figure 5, income inequality is approximated by the ratio of total income of the richest quintile to that of the poorest quintile. The combination of these two factors—a large share of underground economy and a very high officially estimated income inequality—is remarkable. It is open to speculation what is the actual extent of income inequality among households, if unreported income is taken into account. Our approach intends to shed more light on this important topic and to complement officially published information.

The use of car prices for measuring economic inequality was earlier advocated in a pioneering study of Kholodilin and Siliverstovs (2012). The authors show that in Germany, regional measures of economic inequality based on the official data are highly correlated with inequality measures based on regional car prices posted on the internet. Moreover, it was also found that there is a rather high correlation between the official estimates of regional income levels and recorded average regional car prices, suggesting that in relatively poor (eastern) federal states, people tend to demand smaller and cheaper cars than in the better-off western federal states.

The novelty proposed in this paper is that we utilize the information contained in the state register of personal cars in Latvia for measuring economic inequality among households. For every reported car (make, model, year of production) we approximate its value by a prevailing market price. By matching cars with their corresponding prices, we are able to construct a proxy for economic

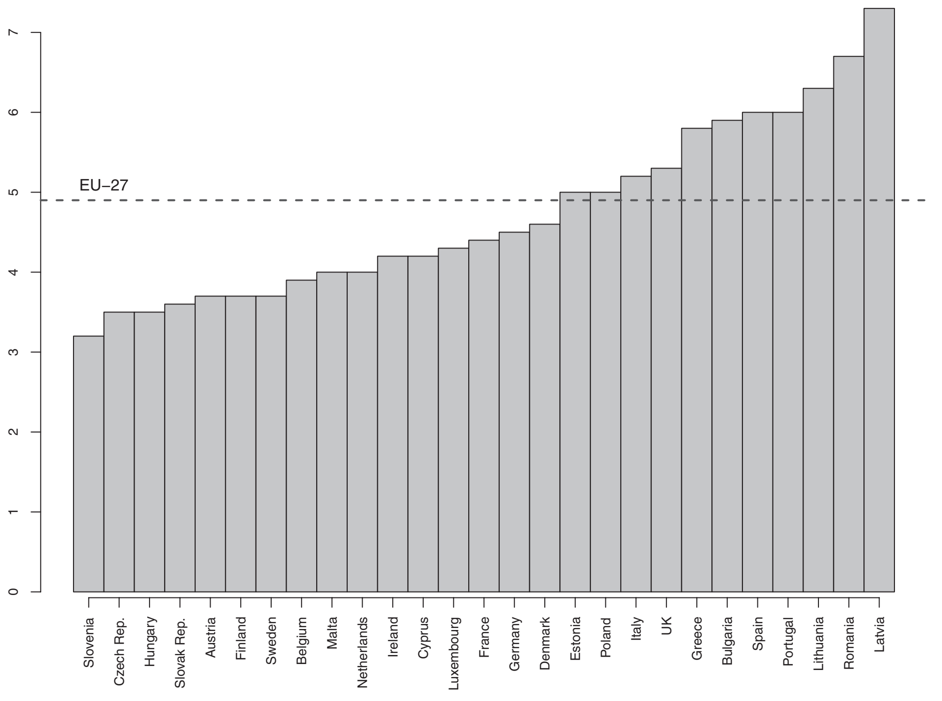

Figure 5. Income Inequality in the EU-27 Countries in 2009: Top-to-Bottom Income Quintile Share Ratio

Source: Eurostat (2012), European Union Statistics on Income and Living Conditions (EU-SILC).

well-being of Latvian households that we can use for measuring economic inequality. In contrast to official measures of income inequality, our method does not have any significant publication lag and is very inexpensive. We also show how to take into account an inherent uncertainty in pricing of the cars by constructing confidence intervals around our estimates of economic inequality.

The rest of the paper is structured as follows. The data used in our study are described in Section 2. The results are presented in Section 3, followed by Section 4, where we discuss assumptions behind our approach and evaluate the possible effects of deviations from these assumptions. The final section concludes.

2. Data

The data on personal cars registered in Latvia were graciously provided by the Latvian Road Traffic Safety Directorate (CSDD). The car pool comprises those cars that were registered on December 31, 2009. Only those cars were included that passed the compulsory technical examination. The data are anonymized and highly aggregated. We have only the following information at our disposal: car make, name of model, year of production, owner type (private or organization), and the corresponding number of cars. Unfortunately, any information on either mileage or engine volume is absent. Neither do we have any geographical information on where cars are registered.

In total, 510,959 personal cars were registered on December 31, 2009 in Latvia. For our estimations we retained only those cars that were built after 1980. The reason for such a choice is twofold. First, it is quite difficult to evaluate older cars since there is not much price information available. Second, given their age it is very likely that such cars are not that much used for everyday traveling but perhaps are mainly kept for other reasons. We also removed from our sample military cars like the Hummer HMMWVM1151 or VW ILTIS, since it was quite difficult to find prices for such cars. Fortunately, there were not so many of those. In the end we were left with 508,701 cars. These cars were registered by both private persons as well as legal entities (commercial firms and organizations). In practice, it is quite difficult, however, to separate the use of cars for private rather than for business purposes. Hence, our first set of results is based on all cars. We check the robustness of our results by estimating the level of inequality using cars registered by private persons only.

The data on car prices were downloaded from the popular German internet site hosting car selling advertisements (www.mobile.de) in May 2010. In total, we collected 873,796 unique price quotes. We use this rich source of information in order to determine an approximate value of each car registered in Latvia by matching the car characteristics (make, model, production year) in the register with the corresponding information posted on this website.

3. Results

In this section, we present our results. First, we describe the results obtained using all cars registered to both persons and organizations. Then, we briefly report the results obtained using a subset of cars registered to persons.

The bottom line of Table 1 reports that there were 508,701 personal cars registered in Latvia with the earliest year of production 1980 (the stand of December 31, 2009). Using the website (www.mobile.de) we did not find any price for 12,562 of them, which comprises about 2.5 percent. For the rest of the cars we could find at least one price quotation. For those cars for which we did not find any prices, we had to use the available information in order to find out a reasonable price for them. For this purpose we used car categories specified at http://en.wikipedia.org/wiki/Car_classification. Observe that in our approach we mixed classifications referred to as both American English and British English on this website. From each classification we picked up the most detailed breakdown of cars. For example, in the American English classification the "subcompact" class of cars includes "city car" and "supermini" categories of the British English classification, such that in the table reporting the estimation results we used these two categories instead of one. In addition, we distinguished between four subcategories of the "sports" cars. The reason for doing so is that this category of cars is very heterogenous: on the one hand, we have low-price sports cars like the Hyundai S-Coupé, on the other hand, rather expensive cars like the Lamborghini Murciélago.

TABLE 1

Results Obtained for All Cars

	Number			Gini Coefficient (I)				Gini Coefficient (II)			
	(1) Total	(2) Non-matched	(3) Non-matched, %	(4) Mean	(5) S.D.	(6) Max	(7) Min	(8) Mean	(9) S.D.	(10) Max	(11) Min
Microcar	144	0	0.0	0.193	0.010	0.220	0.170	0.186	0.028	0.261	0.136
City car	4,207	177	4.2	0.401	0.002	0.407	0.396	0.396	0.015	0.440	0.364
Supermini	23,044	375	1.6	0.381	0.001	0.383	0.379	0.382	0.007	0.401	0.368
Compact	127,621	5,761	4.5	0.518	0.000	0.519	0.516	0.518	0.008	0.551	0.500
Entry lux	72,395	175	0.2	0.528	0.001	0.530	0.527	0.528	0.014	0.562	0.492
Mid-size	100,068	910	0.9	0.561	0.001	0.563	0.559	0.560	0.010	0.594	0.539
Mid-size lux	65,507	636	1.0	0.530	0.002	0.536	0.524	0.532	0.033	0.733	0.508
Full-size	1,425	548	38.5	0.456	0.006	0.475	0.439	0.450	0.021	0.504	0.394
Full-size lux	7,515	66	0.9	0.581	0.002	0.587	0.573	0.580	0.007	0.599	0.559
Sports (low)	701	26	3.7	0.394	0.004	0.408	0.382	0.390	0.016	0.427	0.351
Sports (mid)	207	4	1.9	0.301	0.008	0.325	0.284	0.302	0.015	0.344	0.263
Sports (high)	72	5	6.9	0.180	0.010	0.207	0.149	0.173	0.016	0.218	0.144
Sports (lux)	138	3	2.2	0.412	0.019	0.492	0.382	0.408	0.018	0.453	0.370
Super	6	2	33.3	0.312	0.081	0.477	0.121	0.237	0.045	0.346	0.137
Ponycar	124	3	2.4	0.361	0.017	0.400	0.312	0.357	0.030	0.443	0.298
Grand tourer	424	17	4.0	0.472	0.004	0.482	0.465	0.472	0.007	0.490	0.456
Convertible	3,804	5	0.1	0.410	0.003	0.415	0.403	0.404	0.022	0.451	0.329
Roadster	501	3	0.6	0.344	0.006	0.359	0.330	0.342	0.012	0.371	0.315
LAV	7,814	7	0.1	0.290	0.001	0.293	0.286	0.288	0.009	0.317	0.269
Mini MPV	4,039	252	6.2	0.256	0.002	0.260	0.251	0.254	0.009	0.279	0.233
Compact MPV	11,848	183	1.5	0.342	0.001	0.345	0.340	0.340	0.008	0.355	0.319
Large MPV	22,124	2,072	9.4	0.448	0.001	0.450	0.445	0.447	0.008	0.474	0.429
Full-size van	3,212	89	2.8	0.449	0.003	0.456	0.442	0.448	0.021	0.517	0.403
LCV	10,710	85	0.8	0.457	0.002	0.461	0.452	0.455	0.011	0.490	0.428
Mini SUV	2,758	395	14.3	0.399	0.003	0.406	0.390	0.397	0.012	0.434	0.360
Compact SUV	16,708	237	1.4	0.322	0.001	0.324	0.319	0.321	0.005	0.339	0.309
Coupe SUV	193	0	0.0	0.270	0.008	0.285	0.245	0.267	0.024	0.336	0.209
Mid-size SUV	15,168	404	2.7	0.380	0.001	0.383	0.377	0.379	0.006	0.397	0.364
Full-size SUV	6,173	116	1.9	0.337	0.002	0.342	0.332	0.335	0.015	0.373	0.302
Mid-size pickup	6	4	66.7	0.256	0.068	0.441	0.127	0.259	0.056	0.463	0.126
Full-size pickup	43	0	0.0	0.313	0.033	0.383	0.224	0.305	0.035	0.383	0.196
Super-duty pickup	2	2	100.0	0.076	0.079	0.158	0.000	0.000	0.000	0.000	0.000
All	508,701	12,562	2.5	0.551	0.000	0.552	0.550	0.551	0.007	0.591	0.544

Notes: In columns (4)–(7) and (8)–(11) we report the descriptive statistics of the distribution of the Gini coefficient calculated according to the first and second procedures; see Section 3. The respective distributions were obtained using 100 random draws.

The left panel of Table 1 provides a breakdown of cars according to the afore mentioned categories. The largest category of the cars is "compact", followed by "mid-size." Also cars belonging to the "entry lux" and "mid-size lux" categories are quite popular in Latvia. The column "Non-matched" reports a number of cars in each category, for which we could not find a single price. In general, we were unable to match prices for older cars that are no longer sold in Germany, Soviet-made cars (like UAZ in "mini SUV"), and American cars (like Chevrolet Lumina or Dodge Intrepid in "full-size").

Since we only dispose of very aggregated information on each car, its evaluation is necessarily confronted with inherent uncertainty that we have to account for. Fortunately, for most cars with characteristics known for us (make, model, year of production) we have more than a single price observation. For example, for the VW Golf produced in 2008 we have 419 registered cars and 4,190 corresponding price quotations. We use these multiple price observations in order to approximate the uncertainty. In order to compute a value of the Gini coefficient we assign prices to cars by the following two procedures. For the sake of illustration we continue with the example of the VW Golf 2008. In the first procedure, we randomly draw (with replacement) a vector of size 419 from available 4190 prices such that each of 419 registered cars gets assigned its own price. We repeat this procedure for every model in our sample, which in the end gives us a vector of assigned prices of length corresponding to the total number of cars (508,701). Now we can use this vector of assigned prices in order to compute the Gini coefficient. In the second procedure, we randomly draw only one price from available the 4,190 prices and assign this price to each of 419 cars. Then we repeat this procedure for every model in our sample and subsequently compute the Gini coefficient. We repeat each of the two procedures 100 times. As a result, we have a distribution of Gini coefficient values. We report the descriptive statistics of this distribution in Table 1 in columns (4)–(7) and (8)–(11) for the first and second procedures, respectively.

We also use these two procedures in order to assign prices to 12,562 cars, for which we could not find any price observation. For those cars without matched prices we assigned a price by exploiting our knowledge about a category to which they belong and a year of production. According to the first procedure, we draw a vector of size corresponding to a number of cars from a set of prices for those cars that were built in the same year and belong to the same class. According to the second procedure, we randomly draw a single price from the mentioned set of prices and assign this price to every car with these characteristics.

Estimation results for all car categories are reported in the last row of Table 1. The mean values of the obtained distribution of Gini coefficients computed by these two approaches are practically the same (0.551, subject to rounding). However, the standard deviations of the respective distributions differ. In the first procedure the variation is negligible (the observed maximum and minimum values of Gini coefficients are 0.552 and 0.550, while the standard deviation is 0.000), whereas the second approach yields maximum and minimum values of 0.591 and 0.544, with the standard deviation of 0.007. A similar conclusion can be reached when comparing estimation results for car classes.

In order to check the robustness of our results we replicated these two procedures using cars registered only to physical persons (see Table 2). The sample size reduces to 428,972 cars, and for 11,411 cars we could not find any price observation. The mean values of the Gini coefficient are 0.534 and 0.533 for the first and second procedures, respectively. These values are very close to those reported for the whole car pool.

The car-based estimates of income inequality are compared to official measures based on household budget surveys. The survey-based measures of Gini coefficients available to us are for the years 1988 (0.225; Rauhmane *et al.*, 2001), 1997 (0.338; Fofack and Monga, 2004), 2000 (0.373; Fofack and Monga, 2004), and 2005 (0.360; CIA, 2011). Since 2005, the values of the Gini coefficient are available from Eurostat. In 2009, the value of the Gini coefficient was 0.374. This value is the highest in magnitude among all the EU-27 countries, as shown in Figure 4. For the European Union taken as a whole, the corresponding value of the Gini coefficient in 2009 was 0.304. These figures suggest that in the aftermath of the breakdown of the Soviet Union and during the following two decades, a very severe polarization of the Latvian society in terms of economic well-being took place. Nevertheless, the value of the Gini coefficient reported by Eurostat is much lower than that reported in Tables 1 and 2.

In sum, our approach to measuring the economic inequality among Latvian households suggests that it is much more pronounced than officially reported. It is interesting to note that the estimated value of the Gini coefficient is practically the same whether we use all the cars registered to both physical persons and legal entities or only those cars registered to physical persons. The main argument for using our approach for measuring inequality in countries with a formidable share of shadow economy is that, on the one hand, respondents are generally less motivated to disclose their true levels of income/expenses in interviews than in countries with smaller levels of underground activity. This may severely distort the officially reported measures of household income inequality. On the other hand, it is in their best interests to provide accurate reports to the register of the road police of what car they drive. Provided that the value of a car can serve as a good proxy for income level of a corresponding household, in our approach we can (at least, partly) correct for such a survey bias in assessing the extent of economic inequality in these countries.

4. Discussion

The results reported in the previous section state that household income inequality in Latvia—already by all means high compared to the other EU-27 countries—may be even much higher than officially assumed. Our approach, however, is based on several assumptions, which will be discussed below. We also will speculate on how deviations from these assumptions might influence estimated values of the Gini coefficient in our approach.

The first assumption that we make is that there is no sample selection bias in car ownership. That is, households at each step of income ladder have an equal chance of owning a car. As stated above, in 2009, there were registered 510,959 personal cars in Latvia. The corresponding number of officially counted

TABLE 2

Results Obtained for Cars Registered on Private Persons

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Number			Gini Coefficient (I)				Gini Coefficient (II)			
Class	Total	Non-Matched	Non-Matched, %	Mean	S.D.	Max	Min	Mean	S.D.	Max	Min
Microcar	121	0	0.0	0.191	0.011	0.228	0.170	0.176	0.036	0.276	0.117
City car	3,541	176	5.0	0.433	0.003	0.441	0.426	0.427	0.017	0.473	0.391
Supermini	18,293	371	2.0	0.413	0.001	0.414	0.411	0.412	0.008	0.430	0.393
Compact	109,860	5,599	5.1	0.518	0.001	0.520	0.517	0.518	0.011	0.557	0.490
Entry lux	68,508	159	0.2	0.497	0.001	0.499	0.495	0.495	0.017	0.546	0.457
Mid-size	89,882	865	1.0	0.533	0.001	0.536	0.530	0.533	0.014	0.569	0.501
Mid-size lux	59,177	551	0.9	0.492	0.003	0.504	0.486	0.487	0.017	0.616	0.463
Full-size	1,178	522	44.3	0.424	0.007	0.445	0.410	0.417	0.026	0.492	0.356
Full-size lux	5,993	49	0.8	0.553	0.003	0.562	0.548	0.552	0.008	0.580	0.528
Sports (low)	622	26	4.2	0.403	0.005	0.418	0.390	0.402	0.022	0.442	0.338
Sports (mid)	151	4	2.6	0.311	0.010	0.336	0.286	0.313	0.017	0.363	0.280
Sports (high)	41	5	12.2	0.228	0.017	0.275	0.189	0.226	0.021	0.282	0.176
Sports (lux)	79	1	1.3	0.477	0.019	0.604	0.450	0.475	0.028	0.619	0.416
Super	2	0	0.0	0.192	0.075	0.352	0.151	0.200	0.081	0.352	0.151
Ponycar	114	3	2.6	0.355	0.017	0.404	0.311	0.350	0.035	0.433	0.264
Grand tourer	263	16	6.1	0.515	0.006	0.529	0.500	0.514	0.010	0.539	0.482
Convertible	3,176	4	0.1	0.371	0.003	0.376	0.366	0.366	0.022	0.409	0.311
Roadster	412	3	0.7	0.331	0.007	0.347	0.314	0.328	0.015	0.380	0.299
LAV	1,946	6	0.3	0.358	0.003	0.365	0.353	0.357	0.013	0.387	0.330
Mini MPV	3,349	221	6.6	0.256	0.002	0.260	0.251	0.251	0.012	0.278	0.218
Compact MPV	9,166	135	1.5	0.346	0.001	0.350	0.344	0.345	0.010	0.368	0.326
Large MPV	18,855	1,844	9.8	0.405	0.001	0.408	0.402	0.402	0.009	0.421	0.382
Full-size van	2,056	58	2.8	0.397	0.004	0.405	0.388	0.391	0.024	0.448	0.320
LCV	6,159	47	0.8	0.418	0.003	0.425	0.412	0.413	0.015	0.448	0.374
Mini SUV	1,809	308	17.0	0.392	0.005	0.404	0.383	0.389	0.016	0.438	0.352
Compact SUV	11,487	147	1.3	0.350	0.001	0.353	0.348	0.350	0.007	0.368	0.333
Coupe SUV	95	0	0.0	0.304	0.011	0.334	0.279	0.294	0.027	0.378	0.234
Mid-size SUV	9,504	210	2.2	0.398	0.001	0.401	0.395	0.398	0.006	0.412	0.384
Full-size SUV	3,101	80	2.6	0.382	0.003	0.388	0.376	0.381	0.017	0.425	0.349
Mid-size pickup	3	1	33.3	0.282	0.072	0.478	0.119	0.290	0.081	0.478	0.095
Full-size pickup	29	0	0.0	0.308	0.036	0.389	0.214	0.306	0.045	0.405	0.171
All	428,972	11,411	2.7	0.534	0.000	0.535	0.533	0.533	0.005	0.551	0.522

Notes: See Table 1.

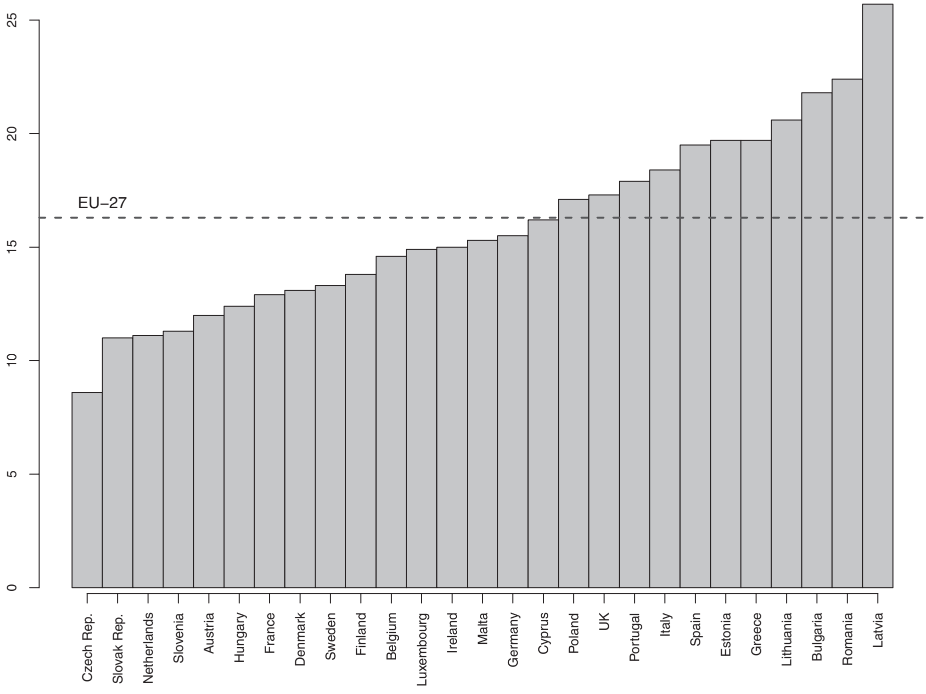

Figure 6. Total At-Risk-of-Poverty Rate in the EU-27 Countries in 2009
Source: Eurostat (2012), European Union Statistics on Income and Living Conditions (EU-SILC).

households in 2009 was 8,886,000. Assuming that the lion's share of households possesses only one car, which leaves us with slightly less than 400,000 carless households, or about 42 percent of total household number. This is still a relatively large number, but under this assumption, stating that the propensity to own a car is equal across households with different income levels, a share of car-owning households can be regarded as a representative subsample, on which basis more general conclusions regarding the whole sample of households can be drawn.

In practice, however, this assumption may not be entirely fulfilled. As noted above, even by taking the official measures of income inequality for granted, there is a very big gap between Latvian households in the top and bottom quintiles of income distribution (see Figure 5). These figures are also consonant with the fact that the poverty rate in Latvia is the highest one among all the EU-27 member states. In 2009, it was about 26 percent measured across all population groups by age and gender,[5] as shown in Figure 6. This implies that households with incomes below or around the poverty line are less likely to own a car than an average household, as the former group of households, for example, with retired or unemployed people, simply cannot afford it.[6] To give an example, the poverty rate

[5]This poverty rate is defined as at risk of poverty rate (cut-off point: 60 percent of median equivalized income after social transfers).

[6]At the same time, members of those households are more likely to be engaged in underground economic activity, compensating for the lack of official income.

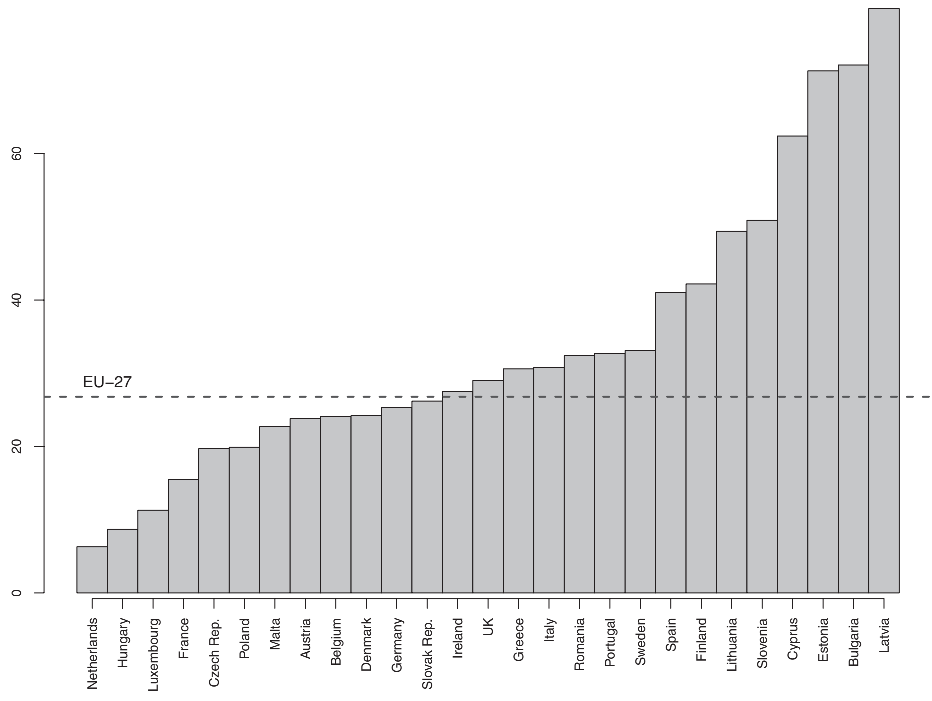

Figure 7. At-Risk-of-Poverty Rate of Persons Aged at 65 and Over in the EU-27 Countries in 2009
Source: Eurostat (2012), European Union Statistics on Income and Living Conditions (EU-SILC).

among Latvian households with one adult aged 65+ is close to 80 percent and again is the highest across all the EU member states (see Figure 7). Clearly, the car ownership rate in such a household is much lower than in an average household.

In order to acknowledge the fact that for certain types of households the propensity to own a car is much lower than for other types, we have to modify our first assumption. We do that by stating that the households with incomes (well) above the poverty line are equally likely to own a car irrespectively of their actual income level. For this category of households the differences in income are assumed to be adequately reflected in the values of owned cars. At the same time, in our approach, accounting for the households that cannot afford a car is equivalent to adding very low prices to those prices that we already have. This would imply that our estimates of the Gini coefficient interpreted under the original first assumption are conservative. Thus, properly acknowledging for the households living below the poverty line is likely to increase further the estimated value of the Gini coefficient.[7]

[7]Proper accounting for households actually living below the poverty line is a non-trivial task in the presence of the rampant share of officially unrecorded economic activity in the Latvian economy. Here, the biggest problem is how to separate those households that are poor indeed and those households that appear as poor in the official statistics but earn the lion's share of their income from underground activity. In our opinion, this could be done by matching their material possessions (including cars, as done in the present study) with economic information reported to governmental agencies by these families. This requires much more information than we actually have and hence is beyond our study.

Our second assumption is that the elasticity of expenditure on a car with respect to income is positive and close to unity. The positive sign of the elasticity indicates that with rising incomes, households on average prefer to buy more expensive cars, signaling improvement in their economic well-being. The assumption of unitary elasticity implies that expenditure share on a car out of household income (here approximated by car prices) is on average the same not only for households with a similar income level but it also holds for all households regardless of their income levels. This assumption is based on a well established link in the literature between income and expenditure on transport (Schafer, 2000). In absolute terms, there is a positive relationship between income and transportation expenditure, including public transport, operation of personal vehicles, and purchase of vehicles. Moreover, according to the conclusions stated in the Indicator Fact Sheet on expenditures on personal mobility:[8] "The share of household expenditures on transport appears to be relatively stable across time, countries, and income groups, exceptions left aside." This Indicator Fact Sheet summarizes information from household budget surveys collected across EU member states on the basis of Eurostat (2004).

These results are reported for broadly defined transport expenditures, from which budget allocated for vehicle purchase is only one component directly related to our study. It is also reported that expenditure shares on public transportation and operation of personal vehicles are comparatively more stable across income groups than a share of outlays for vehicle purchases. Households at the lower and higher tails of income distribution tend to correspondingly underspend and overspend on car purchases compared to middle-income households. This is consistent with the literature that finds that financially constrained households, for example, including retired and unemployed people, view cars as a necessity good and therefore care mostly about actual transportation services that a car provides rather than about other beneficial aspects of owning a car. However, for rich households, such motives as crave for luxury and status symbol play a more prominent role in deciding how much to spend on a car.

In the academic literature, the range of estimates of income elasticity of demand for automobiles is quite broad. On the lower end, Train (1986) and Hess (1977) report estimates of 0.10 and 0.26, respectively, signifying very low demand sensitivity to income. However, as summarized in Bordley and McDonald (1993, table 3), most of the studies report estimates in the range of 0.7 to 2.5. McCarthy (1996) also concludes that elasticities reported in the literature are generally greater than 2.0, indicating a rather large demand sensitivity to income changes. Bordley and McDonald (1993, table 2) report an estimate of aggregate income elasticity of about 2.0 but argue that it varies across different car classes. For example, for economy and small cars, income elasticity is about 1.55; for compact, mid-size, sporty, and large-segment cars it is about 2.0; whereas for luxury-segment cars, it is about 3.0. The reported above estimates of income elasticity are obtained using data for the U.S. or Western Europe. It is not entirely clear to what extent these findings generalize to countries of the former communist block. Anyway, we are

[8]Available at http://www.eea.europa.eu/data-and-maps/indicators/expenditures-on-personal-mobility-1 (accessed April 23, 2012).

not aware of any study that specifically addresses this question for East European countries in general and Latvia in particular. If we take at face value the findings that income elasticity of demand for cars is above unity, then this would imply that richer households spend an overproportionate share of their household income for vehicle purchase. Such a tendency of rich households to overspend on their cars would imply that our estimates of household income that is inferred from the corresponding car values is exaggerated for this household category. If this were the case, then our estimates of inequality among all households in Latvia tend to be upward-biased. The size of this bias depends on the actual value of income elasticity as well as on the distribution pattern of households according to their income. The latter, in turn, is reflected in the true but unobserved state of household economic inequality that we try to measure.

Following the suggestion of a referee we investigated by how much the income elasticity is larger than one could contribute to the upward bias in our estimates of the Gini coefficient. The details of how we addressed this issue are presented in the Supplementary Appendix, but the main idea is to adjust the observed prices to those that would be consistent with the assumption of the unitary income elasticity, and then use them for computing the Gini coefficient. In the adjusted data the bias is attenuated, implying that the true underlying household income inequality could be estimated more accurately. The bias magnitude in estimating the Gini coefficient then is inferred by comparing its values computed from the original and adjusted prices.

As explained in the Appendix, we use the following formula in order to recover car prices that are consistent with the unitary income elasticity:

$$y_i^* = y_0^* + \frac{y_i - y_0^*}{\eta}, \quad i = 1, \ldots, n, \tag{1}$$

where y_i are observed car prices matched to a particular car in the state register. The parameter η is the income elasticity that depends on a car category. Following Bordley and McDonald (1993) we impose the income elasticity of 1.55 for small cars and 3 for luxury-segment cars. For the rest of the categories the income elasticity is set to 2. The use of this formula requires a numeraire price y_0^*, which we set to the average monthly gross salary/wage earned in Latvia in the fourth quarter of 2009. It is equal to 440 LVL or 628 EUR according to the Central Statistical Bureau of Latvia.[9] The obtained value of the Gini coefficient calculated from the adjusted prices is 0.480, which is lower than 0.551 reported in Table 1 but still exceeds the official figure. This allows us to conclude that the bias in estimates of the Gini coefficient based on car prices definitely plays a non-negligible role, but it alone cannot account for the discrepancy between our and official estimates.

The third assumption that we make is that there is only one car per household. This certainly may be true for families with lower income but may not hold for richer families, where both husband and wife may each have a car to drive.

[9]We applied this formula only to car prices that are larger then the numeraire price. All matched car prices that are lower than the chosen numeraire price were substituted with the numeraire price.

Although we do not have any information on car ownership per household, we can conjecture that accounting for this fact would result in even higher values of the Gini coefficient, *ceteris paribus*. By pooling the values of cars, each driven by a husband and wife from the same household, we increase the implied value of their household income, resulting in a smaller number of households at the upper tail of income distribution.

In our car evaluation exercise, we deployed German prices. In doing so we implicitly assume that the price structure of the German car market is similar to that in Latvia. To a certain extent, this seems to be not far away from the truth as most of the (second-hand) cars are imported to the Latvian market from Germany and no customs duties are charged, since both countries belong to the European Union. An advantage of using the German prices is that it helps us directly match prices to a corresponding car for more than 97 percent of the registered cars. As an alternative we could have used the local prices in order to determine an approximate price for a car. But compared to almost 900,000 price quotations available in Germany, there are only about 4500 prices that we could find on the Latvian website publishing car sale announcements (www.ss.lv) This number is substantially smaller, implying that for a large portion of cars it is not possible to directly find the corresponding prices. Moreover, German prices are also more heterogenous for a given set of characteresitcs (make, model, year of production) that we have at our disposal, allowing us to better account for evaluation uncertainty of cars with these characteristics.

Finally, we acknowledge that the prices placed on the web are not the final selling but offer prices. The former prices can naturally deviate from the latter but we do not have any information by how much.

All in all, our approach is based on several assumptions, deviations from which are rather likely in real life. As discussed above, these deviations from the assumptions may lead to both under- or overestimation of the true extent of income inequality in Latvia. However, given the information at hand, it is very difficult to accurately assess which effect dominates. However, the main message is quite clear. The income inequality in Latvia that is already at a record level compared with the other EU member states may well be even higher than is officially assumed. The results of our approach provide no evidence against this proposition.

5. Conclusions

In this paper, we suggest an alternative method of measuring the extent of economic inequality between households. Rather than directly asking (a subset of) households regarding their incomes and expenditures, we suggest to infer indirectly their incomes by assessing an approximate value of their cars. We expect that our method delivers more precise results, especially in countries where the lion's share of income is derived from underground activity. In those countries, we expect that the respondents are less likely to provide true answers during the interviews or are less motivated to participate in the budget surveys at all. As a result, inequality measures based on household budget surveys are likely to be downwards biased. In contrast, our approach is based on accurate and easily verifiable information reported by the respondents to the road police register about the cars they own.

As an illustration of our approach we use Latvian data on car ownership. For each car model we assign a corresponding price using information from the internet advertisements placed on the popular German website with car advertisements. We compute the Gini coefficient based on the assigned car prices and find that our estimates of the Gini coefficient are much higher than those reported on the basis of household budget surveys. The officially available estimate of the Gini coefficient for 2009 is 0.374, which is much lower than 0.550 computed on the basis of the observed car prices. When we adjust the car prices in order to mitigate the upward bias in our estimates that arises due to the fact that income elasticity of car expenditures is above unity, our estimate of the Gini coefficient drops to 0.480, suggesting that the discrepancy in our and official estimates of the inequality among Latvian households cannot be solely attributed to this bias.

Acknowledging that our approach is based on a number of restrictive assumptions, we discuss the likely qualitative effects of deviations from these assumptions on the estimated values of the Gini coefficient. We conclude that the level of income inequality among Latvian households that is already very high compared to the other EU countries may, in fact, be even higher. In any case, we do not find any evidence against this thesis based on our alternative approach.

There are a number of relevant extensions of the approach proposed in our paper. For example, had we known places like towns or villages, where cars are registered, it would be possible to estimate the income inequality at the regional level, similar to the earlier application to Germany (Kholodilin and Siliverstovs, 2012). This would provide us with information on regional differences and, more importantly, allow us to spot poverty pockets in Latvia. Also monitoring trends in car ownership over time would allow us to track the course of the economic well-being of Latvian households. Finally, our approach can be easily transferred to similar datasets in other countries, which enables us to develop international comparisons.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix: Unitary Income Elasticity and Bias Correction