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Revaluating the Tanzi-Model to Estimate the Underground Economy

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Abstract

Since the early 1980s, the interest in the nature and size of the non-measured economy (both the informal and the illegal one) was born among researchers in the US. Since then, several models to estimate the shadow and/or the underground economy appeared in the literature, each with its own theoretical pros and cons. In this paper we show that it is possible to overcome earlier expressed criticism of the Tanzi-model (1983). Its lack of a base year without any underground economy can be overcome, by using the natural experiment of the introduction of the Euro. However, this paper also comes up with new criticism. It shows that the crucial relationship of the Tanzi-model between taxes and the demand for cash money is not time robust, hence the model is not useful for estimating the underground economy nowadays. We believe that the change in financial conditions could partially explain the decline in the relevance of taxes as a means to evaluate the underground economy. We build a revised Tanzi model and try to find variables apart from tax evasion incentives in order to explain the underground economy.

Keywords: Underground Economy Estimation, Shadow Economy, Tax Evasion

JEL classification: E26, H26, K42, O17

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Introduction

The notions of black money, tax evasion and illegal trading are concepts familiar to almost every citizen irrespective of his or her level of economic literacy. Hollywood's classics, such as *The Godfather*, transformed a romanticized description of the underground business into a mental scheme for viewers to construct their beliefs upon. Although portrayed in detail in the movies, the "reality" of the underground economy *remains* obscure and its proportions *remain* hard to define and measure.

Terms like the underground economy, the shadow economy, the black or grey economy, are still used quite arbitrarily. Even when looking at the most recent and mostly quoted recent literature, this confusion does not cease. To give an example: Is tax evasion – an activity essential in the Tanzi model we want to test here - part of the shadow economy (Enste and Schneider 2006) or of the underground economy (Schneider and Enste 2000)? Or doesn't it belong to the shadow/underground economy at all, as suggested by Schneider and Enste (2002)?

For Schneider and Enste (2002) the informal sector comprises activities, which are not part of national income accounting. These include, apart from regular activities such as helping neighbors, irregular and criminal activities. The shadow economy is defined by irregular activities (e.g. illicit labor), and the underground economy is defined by criminal activities. According to this view, tax evasion is neither part of the formal nor part of the informal sector, because it does not produce any value added. For this reason, Schneider and Enste (2002) also explicitly criticize the demand for cash approaches, which deal with tax evasion and to which the Tanzi model belongs, for overestimating the shadow economy. Contrary, in Enste and Schneider (2006, p.37) tax evasion is given as an example for the shadow economy (as opposed to drugs and fencing, which are listed as examples for the underground economy). In the money laundering literature, however, tax evasion is seen as part of the underground economy, since it is related to the predicate crime fraud (see Unger 2007), which conforms with the classification presented in Schneider and Enste (2000).

Though each of the classification schemes depends on different criteria which makes the distinctions above understandable, there is clearly a confusion in terminology. This confusion in definitions also shows in what is being measured.

In the following we will use the term which Vito Tanzi - the author of the model we want to investigate- chose: the underground economy. We will use this term in a very broad sense. By doing so, we encompass all types of activities which are currently not measured by statisticians when composing estimates of the national economy i.e. no matter whether they are informal, illegal or criminal activities, and no matter whether they produce value added or are just a transfer of funds. We will also use the terms shadow economy and underground economy largely as synonyms here, though we are aware of the urgent need of commonly accepted and standardized definitions.

This paper looks into Tanzi's (1983) classical approach to measure the size of the underground economy and shows that its implied causality is not time robust.

The underlying intuition was developed, while trying to estimate the size and the dynamics of the European Union's underground economy after the introduction of the Euro, using the monetarist approach developed in the early 1980s by Vito Tanzi. We soon discovered that our data did not support his approach and this led us to question the method's robustness. Before going into our research, it is worthwhile noting *the importance of studying the Underground Economy and the place of Tanzi's model in previous research.*

During the early 1980s in the US, the interest in the nature and size of the non-measured economy was born among researchers. (Tanzi, 1999) This was due to the growing concern that official recordings were not a good fit for the true developments of the economy. Since then, there have been numerous attempts to quantify the underground economy in various countries and using different methods. Apart from diverse assumptions there were common goals: to increase governmental and public awareness of the underground economy and to transform economic policies such that they efficiently address the real economy and increase aggregate social welfare. The question that naturally follows is: *do these distinct measurements of the underground economy converge, and if not, which one is the most reliable?*

A direct measurement of the underground economy would imply voluntary participation in surveys estimating its size and thus relying substantially on the honesty of the surveyed. As scientific measurements strive to be independent of personal speculation and to selection biases, this method cannot be thought as reliable in capturing the size or the dynamics of the underground economy.

In the following, we will present a short *overview of the co-evolution* of five indirect types of explanatory models, while taking into account the pros and cons for each methodology. Schneider and Enste (2002) discuss in detail the evolution of methods to capture the size and the dynamics of the shadow and/or underground economies.

Measuring the Underground Economy: A literature review

The first method implies looking at the difference in *accounted incomes and expenses*. If the latter is greater, then the difference must consist of undeclared income constituting a means obtained through the underground economy. Unfortunately, Thomas (1992) argues that inconsistencies in measurements both unwillingly and willingly, cast serious doubt on the measurements of the shadow economy.

The second approach considers *labor as an input factor* for both the underground and the legal economies, whereby changes in the labor force indicates the dynamics of the former. The weakness of this accounting method, as stated by Schneider and Enste (2002), is that it does not allow for changes in the labor force that are inherent and independent from the underground sector. Therefore, an ageing population might reflect a lower share of workers to total population without implying a proportional increase of the shadow economy. In addition, illegal migrants and other social groups not working in the legal sector might have a significant impact on the measurements.

The third approach developed by Kaufmann and Kaliberda (1996) and Lacko (1996) considers capital to be the main indicator of the underground economy, referring mainly to *electricity consumption*. The criticism Schneider and Enste (2002) present to both models is that they can neither account for exogenous changes in electricity use, nor can they capture the interpersonal

unaccounted trade that makes little use of capital. The critics also argue that indexing countries according to electricity/GDP and using an estimation of the shadow economy in one base country to compute the underground economies of the other countries in the sample assumes constant possibly important country and culture specific factors.

The fourth approach is referred to as the *MIMIC models* which bring together expected causes and effects (or indicators) of the underground sector. These are said to be easily observed as opposed to the real underground economy. The underlying idea is that we can use measurements of both the causal and of the indicator variables, in a time frame to infer the movements of the intermediate/ middle value: the unobserved size of the underground economy, which then is reported in percentage of GDP (Dell'Anno and Schneider, 2003). This method, although seemingly more complex is heavily criticized by Breuch (2005) who argues that it is vague in its specification, sensitive to the units of measurement and hard to reproduce (hence possibly subjective). Breuch (2005) also argues that the MIMIC model relies too much on the public's interest in large estimations. Moreover, the MIMIC model measures only the change in the size of the underground economy and not the actual size of the underground economy. This means that estimations from another source are needed for the base year, a weakness that to our surprise is passed on by Schneider and Enste (2002) as a critique to the Tanzi-model.

The fifth method is *the monetarist approach* developed by Feige (1979) and Tanzi (1983). Feige (1979) tried to estimate the size of the US economy from the perspective of payments and transactions. He assumed the aggregate money supply to be a good indicator of the size of the real economy and made estimations based on the Fisher $MV=PT$ equation. This equation says that money M times the velocity V equals the price level P times the level of transactions T in an economy. Tanzi (1983) used the constructed aggregate money demand of Feige (1979) and compared it to the recorded money supply. He then suggested that the overall excess of money supply was unrecorded money used in the underground economy.

By means of this short literature review we hope to have shown the substantial difference in approaches. This would not necessarily be a disturbing fact had the resulting measurements be convergent, which Tanzi (1999) argues is far from reality.

The methodology of the Tanzi model

As previously discussed, Tanzi (1980) constructed an estimate of the money demand, using the model of Feige (1979), and compared it to the recorded money supply in the US, using yearly data from 1929 to 1980. In his seminal paper, Tanzi (1980) suggests that one of the main factors that deter individuals from legally transacting in the US is that they have to give away part of these transactions in the form of taxes. Tanzi (1983) started to examine the view of Cagan (1958) who had previously argued that, although cash does not pay interest, it is and will be used as a means to avoid paying taxes.

Focusing thus on tax evasion, Tanzi (1983) builds a model where the ratio of cash to non-cash money supply is generated by the ratio of personal income tax to total adjusted income, the ratio of legal cash remuneration to total personal income, the interest rate, and real income per capita.

The regression he used is presented hereunder.

$$\ln\left(\frac{C}{M_2}\right) = \beta_0 + \beta_1 \ln(T) + \beta_2 \ln\left(\frac{WS}{NI}\right) + \beta_3 \ln R + \beta_4 \ln(Y) + \mu \quad (1)$$

In this regression, the cash to money supply ratio (C/M_2) is influenced by the personal income tax rates (T), the amount of cash wages to national income (WS/NI), the annual interest rates (R) and income per capita (Y). Note that the natural logarithm of the variables is used instead of the actual values, which makes it a multiplicative multivariate estimation model. For the actual data, see appendix 1.

Tanzi (1983) uses regression (1) to estimate the relation between taxes and cash to money supply. He then chooses a base year where he assumes there is no underground economy and uses the estimated coefficient for tax rates and the actual development of tax rates to estimate how much cash is used in the underground economy. Finally, the amount of non-disclosed transactions (i.e. the size of the underground economy) is found by using the Fisher equation, where Tanzi (1983) assumes the velocity of “black money” to be similar to that of legal funds. Naturally, this estimation is only possible when the coefficient for tax rates is found to be significant and positive, and therefore, relationship (1) is crucial to the model.

This methodology that has been pioneered in the early 1980's has remained one of the foremost used tools to measure the developments of the underground economy. We would argue it is the intuitive aspect of this model that makes it so attractive to both academics and the large public, especially as the relationship the model encapsulates, has proven resistant to a number of new econometric developments. In the next section we will show the survival power of the Tanzi-model against earlier criticism.

Correcting the Tanzi model in reaction to earlier criticism

Although presenting robust results, Tanzi's (1983) method was criticized by Schneider and Enste (2002) who argued that he assumes a base year for which there is no shadow economy without enlisting reasonable grounds for doing so, that there is more to tax evasion than the size of tax rates (i.e. tax morality, trust in the government etc). Further they argue that he does not take into account the usage of the dollar abroad as international currency and finally, that in the particular case of the US, increases in currency demand could also be due to an exogenous decreasing demand for deposits over the respective time period.

We will now continue to show that these points of critique are *not crucially* targeting the external validity of Tanzi's (1983) results. We will show that we can *address and to a large extent eliminate these points of critique* if we apply the model to the Euro zone, after the introduction of the Euro in 2001.

The model we have worked on is similar to that of Tanzi (1983).

$$\ln\left(\frac{M_1}{M_3}\right) = \beta_0 + \beta_1 \ln(1+T_n) + \beta_2 \ln(1+GT) + \beta_3 \ln\left(\frac{WS}{Y}\right) + \beta_4 \ln R + \beta_5 \ln\left(\frac{Y}{N}\right) + \beta_6 \ln\left(\frac{D}{C}\right) + \mu \quad (2)$$

It showed (as presented above) the cash to money supply ratio (M1/M3)¹ as depending on different tax rates (T_n), taxes collected by different forms of government (GT), the amount of income received in cash to personal income (WS/Y), interest rates (R), income per capita (Y/N) and the size of the captured drugs activities per unit of consumption (D/C) (see appendix 2 for a

¹ Because of differences in aggregation levels used in EU-data en US-data, we could not produce a time series C/M2 for the EU. We think that the ratio M1/M3 for the EU is the closest related to the ratio C/M2 in the US.

detailed description of the data collection). Given the fact that we have data on Money Supply only at a European level, our initial regression was based on European Averages.

Taking the critiques one by one, we could chose the year 2002 as the year with no shadow economy since this was the year of the currency change in the adhering countries. It was not possible at the time to fuel the underground economy by means of Euro cash and coins, as the old currency if illegal could not have been transformed in Euros. Thus the choice of the initial point is not the result of a rule of thumb, but the result of a natural experiment that took place in the European Union. Therefore, we can reasonably eliminate this point of critique.

Addressing the second point of critique, one can group taxes according to the collecting authority (at a national and supranational level) and look at the separate impact. Moreover, one can also include data on drugs trading and therefore address in more detail the specific components of the underground economy: the informal, the illegal and the criminal activities.

As for the last two points of critique, the ECB reports that the introduction of the Euro was surrounded by skepticism from foreign investors and thus was assimilated as international currency only later in its existence². Furthermore, given the increasing expansion of non-cash transactions and services, which corroborates with a period of non-violent economic development, it is unreasonable to assume that the demand for deposits has significantly lowered if at all, between 2002 and 2009 in the Euro zone.

Thus, we believe it is possible to construct a model essentially similar to that of Tanzi (1983) that addresses all critique by expanding its explanatory variables set to account for illegal activities and trust in the Government. However, an argument can be made against this expansion, as we have not dealt with the more abstract points of critique addressed by Schneider and Enste (2002).

² http://www.cesifo-group.de/portal/page/portal/ifoHome/B-politik/10echomitarb/_echomitarb?item_link=ifostimme-FT04-04-01.htm

Correcting for the Unit Root problem

Having constructed this model and having had quite disappointing results, our attention turned to the soundness of the original model for the US³. Having performed a Dickey Fuller test (Dickey and Fuller, 1979) on the data used by Tanzi (1983) we realized that the model suffered of a unit root problem (see Table 1). This means that one OLS requirement, stationarity of the stochastic process, is not fulfilled. If an equation has a unit root in econometrics, the model is underdetermined, which means that both the dependent and the independent variables have a similar trend which is determined outside the model in question. This implies that the model gives a high R-squared without it having any real explanatory power. Granger and Newbold (1974) called such estimates *spurious regression* results.

Furthermore, we observed later research using the Tanzi-model that did not correct for a unit root i.e. Albu et al (2002) and Ahmed and Qazi Masood (1995).

Table 1: Results of unit root testing for variables used in the model of Tanzi (1980)

Dickey Fuller Test on:	Test Statistic	1% Critical value	5% Critical value	10% Critical value	Unit root
Cash to money supply (C/M2)	-2.389	-3.579	-2.929	-2.600	Yes
Tax rate (T)	1.480	3.579	2.929	2.600	Yes
Income per capita (Y)	0.050	3.579	2.929	2.600	Yes

Source: Made by the authors using the data of Tanzi (1983)

Econometric theory suggests it is possible to correct a model with a stochastic process, by taking the first difference of the variables and redoing the regression using the differences instead of the variables in effect. Having changed this in the model of Tanzi (1983) we got regression (3). The coefficients of this regression are depicted in appendix 4.

³ The fact that we had disappointing results is not a matter of interest for this paper. We believe that our disappointing results can easily be due to the lack of sufficient data. We mention this only to inform the reader about the reasons that persuaded us to doubt the method of Tanzi (1980).

$$\Delta \ln\left(\frac{C}{M_2}\right) = \beta_0 + \beta_1 \Delta \ln(T) + \beta_2 \Delta \ln\left(\frac{WS}{NI}\right) + \beta_3 \Delta \ln R + \beta_4 \Delta \ln(Y) + \mu \quad (3)$$

The regression results show that the Tanzi-model survives the unit root critique. The coefficient on taxes is statistically significant and correctly signed over this period. Moreover, the model has a high explanatory power. This means that *the relationship between taxes and the cash to money supply ratio still holds, when correcting for the unit root in the data*. Apparently the variables are integrated of order one and the relationship is not the result of a common trend.

We will now show that despite all our efforts to save the validity of the Tanzi-model by correcting for unit roots, an even greater problem occurred, that seriously endangers the model. This is the lack of time robustness. The causal relationship between taxes and the size of the cash supply is not time robust, even if we take a closer look at the time frame used by Tanzi (1983) himself, and even less so, if we expand it to present day.

New critique on the Tanzi model: Relationship not time robust

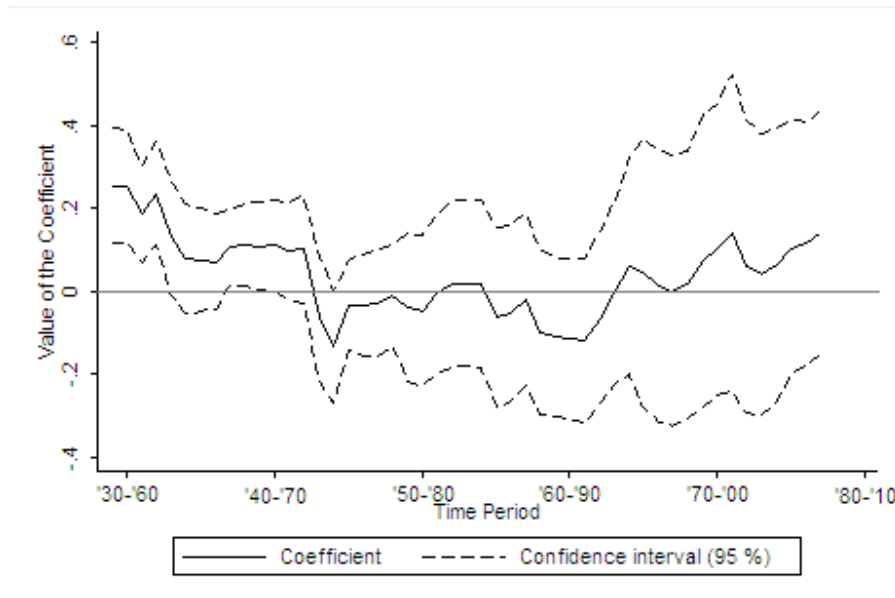
We used the data Tanzi (1983) disclosed in his paper and updated it accordingly until 2006. In order to avoid structural breaks due to new datasets, we collected data from 1975 – 2006, while the data of Tanzi actually ended in 1980. The overlapping 5 years allowed us to control for the quality of our data set merger.

On this extended panel data we ran what in econometrics is called *rolling regressions*. This method allows for a regression to be run on a panel data for given time sub samples. Figure 1 presents the dynamics of the β coefficient of the tax ratio on the cash surplus for 57 consecutive periods of 30 years.

The regression to be rolled was the following:

$$\Delta \ln\left(\frac{C}{M_2}\right) = \beta_0 + \beta_1 \Delta \ln(T) + \beta_2 \Delta \ln\left(\frac{WS}{NI}\right) + \beta_3 \Delta \ln R + \beta_4 \Delta \ln(Y) + \mu \quad (4)$$

Figure 1: Moving tax coefficient for 57 consecutive 30-year sub samples



Source: Made by the authors using regression (4) on the expanded panel data of 1929-2006. One should read this figure as follows: The straight line shows how the coefficient of tax develops over time with 30 year periods (the first observation is 1929-1959, the next observation is the period 1930-1960 etc.) the dashed lines above and under the coefficient line show the confidence interval of the coefficient on a 5% significance level. This means that when zero lies within the confidence interval (like happens for the first time in the period of 1933-1963) the coefficient is not significant different from zero at the 5% significance level.

Figure 1 shows that a significant causal relationship can be identified in the first 4 periods, while the β coefficient approached zero for most of the rest of the sample originally used by Tanzi (1983).⁴ The relationship does not hold in the extended dataset either. Although the coefficient does increase in the latter period, with the standard deviation being so large, it is not a significant relationship.

This result complements the critique of Schneider and Enste (2002). One of their arguments was that the year where Tanzi (1983) assumes the underground economy to be nonexistent is arbitrarily chosen. We would like to point out that even if 1929 were the state of nature with no underground economy, the relationship would still suffer from temporal invalidity. In this sense,

⁴ That the coefficient is significant over the whole period and only really significant in the first four periods is due to the fact that most of the variation in the data takes place in these early years (see appendix 2). If one would take out the first 15 observations (the years 1929-1943), the relation between the tax rate and currency to money supply over the 'whole' period becomes insignificant on a 5%-level, using regression (4).

we believe Schneider and Enste (2002) hinted at the right problem, but did not consistently prove it.

Some explanation of the new results

Tanzi (1983) built a model to estimate the size of the underground economy using taxes as a tool. His model presented robust results at the time of the publication and these results, although suffering from a unit root problem, were intuitively convincing.. When corrected for unit roots, the Tanzi-model still provided significant and correctly signed results. However, a more fragmented analysis of the regression shows that its overall significance is driven by only a relatively short period of time. Only the first time range between 1930 and 1960, confirms the relationship between taxes and excess demand for cash money.

In view of Hume (1740) we cannot infer the existence of a state of nature in the present or future because of its consistent past occurrence. In line with this, it would be wrong to assume away that taxes always positively affect the size of the underground economy, just by looking at a non-falsified hypothesis of Tanzi (1983). The role of science as seen by Popper (1963) is to question these theories and to try to falsify them, as Tanzi himself suggested in “Uses and Abuses of Estimates of the Underground Economy” (1999).

Therefore, using inductivist theory we have shown that once you falsify the Tanzi-model it is not rational to expect the relationship between taxes and the shadow economy to still be present in the way the model initially suggested. This induction however, has no bearing on the truth value of the Tanzi-model upon its publication. Moreover, the correction for a unit root we have done using the data of Tanzi (1983) does corroborate to falsifying his findings especially in the earlier part of his time sample.

If one were to trust in the error elimination process that advances scientific knowledge (Popper, 1994) one should also inquire into the reasons for the due course decomposition of the relationship. Could it be that the model was valid, and the relationship not only present but also powerful enough to represent the size of the underground economy in the early 1930?

A short historical perspective reveals the immense changes of setting that took place in the US since the early 1930 recession, to a point where we can think of almost reversed settings. As

opposed to present times, before the Great Depression US companies were producing at overcapacity and exporting hugely. The US balance of payments implied a strong currency that could not efficiently compete in exports. The domestic market was left to accommodate for non-exported surpluses, the government did not contribute to absorb supply, companies were closed hence unemployment rose, banks' balance sheets contracted and the situation spiraled out of control (Eichengreen, 1992).

Bearing in mind the historical context, could it be that major capital outflows combined with the soaring unemployment caused by the dismissal of national industries had an impact on the view people took towards taxes? Could it be that in the face of such financial hardship to which the government was not seen to actively contribute to ameliorate, intuitively people lost faith in their government and sought to avoid paying taxes? When discussing the approach of Feige (1959), Tanzi (1980) also mentions government's perceived reliability to be one factor non-accounted for, but with a significant toll on the size of the underground economy.

We believe that as a result of the economic climate present in the US in the early 1930s, taxes could have been used as an instrument to uncover the dimensions of the underground economy. However, as the economic climate improved and taxes regained their endorsement from the public moral, such a method might have lost its ability to grasp the reasons for the existence of the underground economy.

A revised Tanzi model for the underground economy?

The fact that the Tanzi model turned out not to give a convincing explanation of today's underground economy, does not necessarily mean that the model per se is wrong. Could it be then that Tanzi's idea of defining the underground economy by the amount of excess demand for cash is right, and that tax evasion is no longer the appropriate explanatory variable? If Tanzi's intuition that people, who want to hide income or wealth from the government for whatever reason, hold it in cash money is right, then excess cash holding might still be a good proxy for estimating the underground economy. Other factors than tax evasion due to high tax rates might then explain this underground economy.

Unemployment might have an impact on the shadow economy. Increased unemployment might lead to a crowding out of illegal low skilled workers by legal higher skilled workers, who – under the threat of being unemployed otherwise – might accept lower paid jobs. There might therefore be a negative relationship between unemployment and the shadow economy (which according to our model pays in cash). But unemployment can also be an incentive for entrepreneurs to hire more illegal workers in order to save costs in difficult times; hence there might be a positive relationship between unemployment and the shadow economy. We therefore tried to use unemployment figures instead of tax rates in our revised Tanzi-model.

In the literature also a number of other key factors that influence the underground economy are put forward. Schneider and Enste (2000) and Blackburn, Bose and Caposso (2009) give a literature overview over these factors influencing the underground economy.

Underground activities can be influenced by public policy and public administration. Apart from the burden of taxes and social security, the complexity and arbitrariness of the tax system, the extent of bureaucracy and regulations, and corruption are mentioned. Perhaps these factors have nowadays become more important than taxes and tax rates for the underground economy. We operationalized some of these public policy and public administration factors by adding to the tax rate as used in Tanzi (1983), the amount of government expenditures in relation to GDP (measured as a share/percentage), police expenditures (measured in amount of dollars and amount of dollars per capita) and judicial expenditures (also measured in amount of dollars and amount of dollars per capita).

Since the underground economy includes also criminal activities, the underground economy could be largely influenced by those crimes that generate the most (cash) money. When thinking about crimes that generate relatively large amounts of (cash) money, drugs are normally mentioned as a stylized fact. But it could be, of course, that other (property) crimes also influence the size of the underground economy. We operationalized these crimes by using the total crime rate (measured in the amount of crimes and amount of crimes per capita), statistics on the amount of drugs use (as a proxy for the size of the drugs market), the amount of robberies, burglaries, larceny-thefts, vehicle-thefts, property crimes in general (all measured as a frequency) and corruption (measured as a perception index). We included corruption specifically because it could facilitate tax evasion.

Another factor that could influence the shadow economy is literacy and inequality. The World Bank argues that illiteracy prevents people from opening bank accounts and forces them into the cash economy and often also shadow economy (World Bank, 2006). We operationalized this indicator by taking the percentage that completed less than 5 years of elementary school and the percentage that completed high school as proxies for respectively illiteracy and literacy. We checked the robustness with respect to gender and race. The cash intensive part of the underground economy can be one of low skilled workers and poor people rather than one of rich tax evaders, who can probably find other – less cash intense – means for their activities. What the French author Anatole France noted already at the beginning of the twentieth century, could still to be true today: ‘It is only the poor who pay cash, and that not from virtue, but because they are refused credit’. This result is supported by findings of anthropologists in the US, who talk about ‘the cash ghetto’ implying that ghettos are very often forced into the informal sector because of lack of formal structures there and have to trade with cash money (Weatherford, 1997). We operationalized inequality with income inequality statistics that can be calculated using a Lorenz-curve on income (the Gini-index of income inequality).

We estimated the Tanzi model for the US by including at least one indicator for each of the arguments listed in the literature as key factors influencing the shadow economy. Table 2 lists the variables we used, their source, the period for which these data were available and the results of using these variables in the following regression:

$$\Delta \ln \left(\frac{C_{domestic}}{M_{2domestic}} \right)_t = \Delta \ln Y_t + \Delta \ln R_t + \Delta \ln \left(\frac{WS}{NI} \right)_t + \Delta \ln(Variable_of_Interest)_t, \quad (5)$$

Note that the left hand side has changed compared to the original regression (4). We corrected here for the amount of US dollars used outside the US. The Fed publishes figures on the total amount of US dollar in circulation outside the US since 1965.⁵ By doing so, we want to

⁵ Publicly available at:
http://search.newyorkfed.org/ny_public/search?source=frs_pub&text=u.s.+currency+held+outside+the+united+state&search=Search

strengthen the estimation model, since the international use of US dollars has been criticized as a weakness of the model (Schneider and Enste, 2002)⁶. The right hand side of equation (5) lists Y (per capita income), R (the annual interest rates) and WS/NI (cash wages to national income) as control variables and the potential candidate from the literature that might influence the shadow economy.

Table 2: Potential candidates for a revised Tanzi model.

Variable that influences the shadow economy	Data source	Period	Result
Unemployment rate	Bureau of Labor Statistics	1948-2009	Insignificant effect
<u>Public policy and public administration variables</u>			
Tax rate	Tanzi (1983) and IRS.gov	1929-2006	Significant positive effect, but not time robust, see figure 1
Government expenditures as a share of (real) GDP per capita	Penn World Table	1950-2007	Insignificant effect
Police expenditures	Bureau of Justice Statistics	1982-2006	Insignificant effect
Judicial expenditures	Bureau of Justice Statistics	1982-2006	Insignificant effect
Police expenditures per capita	Bureau of Justice Statistics	1982-2006	Insignificant effect
Judicial expenditures per capita	Bureau of Justice Statistics	1982-2006	Insignificant effect
<u>Crime variables</u>			
Total crime rate	FBI Uniform Crime Reports, Disaster Centre	1980-2008	Insignificant effect
Total crime rate per capita	FBI Uniform Crime Reports, Disaster Centre	1980-2008	Insignificant effect
Drugs use	The White House, National Drug Control Strategy	1990-2007	Insufficient data. (We also have data for 1979, 1982, 1985 and 1988, but these can't be used in this type of analysis because these are not consecutive years)

⁶ We did not correct for the international use of US dollars in the analysis leading to figure 1, since we have this data only from 1965 onwards, which means we cannot replicate the results of Tanzi (1980) in the period 1929-1980.

Amount of Robberies	FBI Uniform Crime Reports, Disaster Centre	1980-2008	Insignificant effect
Amount of Burglaries	FBI Uniform Crime Reports, Disaster Centre	1980-2008	Significant negative effect but with the unexpected sign
Amount of Larceny-thefts	FBI Uniform Crime Reports, Disaster Centre	1980-2008	Insignificant effect
Amount of Vehicle thefts	FBI Uniform Crime Reports, Disaster Centre	1980-2008	Insignificant effect
Amount of Property crimes	FBI Uniform Crime Reports, Disaster Centre	1980-2008	Insignificant effect
Corruption	Transparency International	1995-2009	Insufficient data
<i>Literacy and inequality variables</i>			
Percentage that finished less than 5 years of elementary school	National Center for Education Statistics	1962-2009	Insignificant effect
Percentage that finished high school	National Center for Education Statistics	1962-2009	Significant negative effect for males, but not time robust, see the figure in appendix 4
Income inequality	US Census Bureau	1967-2009	Insignificant effect

All above mentioned results are evaluated at a 5% significance level. All detailed regression results for the last column, are shown in appendix 4. We have tested the robustness with respect to time, correcting for the international use of US dollars, the three control variables Y, R and WS/NI and other significance levels. These robustness checks are not shown here to keep the table readable, but they can be retrieved by contacting the authors.

Interpretation of the results

As can be seen in table 2, the revised Tanzi - model still looks very poor, since we could not find a good alternative for the tax rate used by Tanzi (1983) as an explanation for excess cash demand. We tried a large amount of different variables to capture different parts and aspects of the shadow economy, without a fruitful result. For those who want to continue our efforts and save the Tanzi - model, we advise to focus on tax complexity and tax morale (see e.g. Torgler and Schneider, 2009), since we have not tested these variables yet.

Conclusion

With this paper we have attempted to consistently falsify the model of Tanzi (1983). In due process we have drawn the reader's attention to the works of his critics, to what their doubts were and concluded that they did not advertently falsify his theory. Although past economic conditions could have contributed to its past high explanatory power, we show by means of new econometric techniques that Tanzi's (1983) model for estimating the underground economy currently lacks external validity. High tax rates seem to be no longer the major driving force for holding excess cash money. Also other variables, like unemployment, public policy, crime, literacy and inequality do not seem to explain the shadow economy measured by excess cash demand. Which leaves us to question which other factors might explain the underground economy and whether the underground economy can be measured at all nowadays by estimating the excess cash demand?

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Appendix 1: The data for the US, 1929-2006, to draw figure 1

Year	C	M2	T	Y	WS/NI	R	Year	C	M2	T	Y	WS/NI	R
1929	3,64	46,60	4,04	2,58	59,50	3,34	1968	41,80	364,00	13,78	5,24	65,00	4,36
1930	3,37	49,70	2,63	2,31	62,62	3,31	1969	44,70	391,80	14,30	5,32	66,17	4,57
1931	3,65	42,70	1,81	2,11	66,83	2,99	1970	47,60	402,80	13,26	5,25	67,68	4,98
1932	4,62	36,10	2,83	1,81	71,96	2,80	1971	51,00	454,80	12,65	5,35	66,66	4,77
1933	4,76	32,20	3,40	1,76	72,76	2,56	1972	54,30	498,00	12,52	5,61	65,92	4,62
1934	4,65	34,40	4,00	1,89	69,26	2,37	1973	59,20	548,10	13,04	5,96	67,69	5,82
1935	4,78	39,10	4,41	2,04	64,99	1,93	1974	64,50	594,20	13,64	5,89	65,97	7,14
1936	5,22	43,50	6,31	2,30	65,24	1,64	1975	71,00	642,20	13,13	5,78	65,06	5,96
1937	5,49	45,70	5,38	2,39	63,82	1,55	1976	77,70	698,20	13,36	6,04	64,52	5,32
1938	5,42	45,50	4,05	2,28	65,17	1,48	1977	84,30	775,50	13,68	6,32	63,61	5,24
1939	6,01	49,30	4,00	2,43	64,52	1,36	1978	92,80	840,60	14,33	6,57	63,32	5,87
1940	6,70	55,20	4,09	2,59	62,56	1,22	1979	101,80	915,50	14,56	6,72	61,96	7,41
1941	8,20	62,50	6,63	2,98	60,52	1,12	1980	111,00	982,60	15,51	6,65	63,34	8,52
1942	10,90	71,20	11,32	3,40	60,50	1,03	1981	118,95	1254,69	16,09	12,55	55,37	15,91
1943	15,81	89,90	14,65	3,87	62,44	0,87	1982	127,76	1379,95	14,81	13,80	55,68	12,04
1944	20,88	106,80	13,89	4,10	64,29	0,84	1983	140,09	1553,70	13,83	15,54	54,65	8,96
1945	25,10	126,60	14,17	3,99	65,05	0,85	1984	152,01	1682,56	13,75	16,83	53,30	10,17
1946	26,52	139,00	11,97	3,36	62,84	0,82	1985	162,29	1831,78	13,83	18,32	53,64	7,97
1947	26,60	146,00	12,03	3,23	63,25	0,85	1986	174,28	1949,22	14,54	19,49	54,30	6,61
1948	26,00	147,80	9,41	3,31	61,87	0,87	1987	188,61	2042,28	13,12	20,42	54,37	6,74
1949	25,60	147,70	9,01	3,27	63,36	0,90	1988	205,06	2161,30	13,21	21,61	53,95	7,59
1950	25,10	151,00	10,22	3,49	62,24	0,92	1989	217,33	2277,37	13,12	22,77	53,81	9,11
1951	25,40	155,50	11,93	3,72	62,90	1,02	1990	235,07	2416,82	12,95	24,17	54,18	8,15
1952	26,70	164,50	12,87	3,80	64,86	1,14	1991	259,00	2488,11	12,75	24,88	53,94	5,82
1953	27,70	171,10	12,80	3,88	66,27	1,30	1992	279,13	2443,67	12,94	24,44	53,89	3,64
1954	27,50	176,70	11,58	3,76	65,80	1,30	1993	307,85	2367,32	13,32	23,67	53,18	3,11
1955	27,60	183,60	11,78	3,95	64,54	1,36	1994	340,74	2347,78	13,50	23,48	52,27	4,38
1956	27,90	186,70	12,19	3,96	65,83	1,58	1995	366,79	2422,56	13,86	24,23	52,41	5,87
1957	28,30	191,70	12,23	3,96	66,04	2,08	1996	382,32	2631,46	14,34	26,31	52,17	5,35
1958	28,30	201,60	12,17	3,89	66,07	2,20	1997	409,99	2853,58	14,48	28,54	52,34	5,54
1959	29,00	211,00	12,60	4,05	64,61	2,36	1998	442,15	3124,73	14,42	31,25	53,09	5,49
1960	29,00	210,80	12,47	4,08	65,41	2,58	1999	486,34	3413,14	14,85	34,13	53,36	5,19
1961	28,90	223,40	12,76	4,11	65,17	2,73	2000	522,77	3681,45	15,26	36,81	54,01	6,35
1962	30,00	236,60	12,83	4,28	64,51	3,23	2001	555,01	4061,89	14,23	40,62	53,91	3,82
1963	31,50	251,40	13,02	4,39	64,15	3,34	2002	608,95	4403,08	13,03	44,03	53,12	1,72
1964	33,50	266,40	11,84	4,56	64,04	3,47	2003	647,64	4711,81	11,90	47,12	52,24	1,15
1965	35,00	287,40	11,50	4,77	63,24	3,73	2004	680,67	4918,15	12,10	49,18	51,51	1,45
1966	37,00	312,10	11,93	4,99	63,43	4,12	2005	710,10	5155,11	12,45	51,55	50,57	3,34
1967	39,00	335,10	12,42	5,07	64,48	4,32	2006	740,12	5480,92	12,60	54,81	50,44	5,06

Appendix 2: Data sources

For the EU:

M1 and M3: European Central Bank:

<http://sdw.ecb.europa.eu/>

Tax data: The European Commission Taxation and Customs Union report 2009 Report:

http://epp.eurostat.ec.europa.eu/portal/page/portal/national_accounts/data/database

Interest rates, consumption per capita, income per capita and wages and salaries: Eurostat:

http://epp.eurostat.ec.europa.eu/portal/page/portal/interest_rates/data/database

Drugs data: UNODC World Drug Report 2009:

http://www.unodc.org/documents/wdr/WDR_2009/WDR2009_eng_web.pdf

For the US:

M0, M1, M2 and interest rates: Federal Reserve Bank Data:

<http://www.federalreserve.gov/releases/h6/hist/h6hist2.txt> (M1 and M0 in the US 1975 –Aug 2009), <http://www.federalreserve.gov/releases/h6/hist/h6hist1.txt> (M1 and M2 in the US 1975 – Aug 2009), <http://www.federalreserve.gov/releases/h6/hist/h6hist5.txt> (M2-M1 as in Tanzi), <http://www.federalreserve.gov/releases/h15/data.htm#top> (monthly interest on 1-month CDs)

Income per capita, Government share of GDP: Penn World Table:

http://pwt.econ.upenn.edu/php_site/pwt63/pwt63_form.php

Wages and Salaries to personal disposable income per capita: U.S. Department of Commerce, Bureau of Economic Analysis:

<http://www.bea.gov/national/nipaweb/TableView.asp?SelectedTable=58&ViewSeries=NO&Jav>

[a=no&Request3Place=N&3Place=N&FromView=YES&Freq=Qtr&FirstYear=1975&LastYear=2009&3Place=N&Update=Update&JavaBox=no#Mid](#) Transforming the real income per capita data in 2005 US\$ into 1972 US\$ terms has been done using an inflation calculator, the method and the program easily downloadable at:
http://inflationdata.com/Inflation/Inflation_Calculators/Inflation_Rate_Calculator.asp

Tax data: Internal Revenue Service:

http://www.irs.gov/taxstats/indtaxstats/article/0,,id=96679,00.html#_grp8

Crime data: FBI Uniform Crime Reports, Disaster Centre:

<http://www.disastercenter.com/crime/uscrime.htm>

Police and Judicial expenditures: Bureau of Justice Statistics:

<http://bjs.ojp.usdoj.gov/content/glance/tables/exptyptab.cfm>

Unemployment data: Bureau of Labor Statistics:

<http://data.bls.gov/PDQ/servlet/SurveyOutputServlet>, monthly data, calculated the annual rate: sum of the months/12

Income inequality: US Census Bureau:

<http://www.census.gov/hhes/www/income/histinc/IE-1.pdf> (GINI-index)

Literacy: National Center for Education Statistics:

<http://nces.ed.gov/quicktables/index.asp>

Appendix 3: Overview of regressions

Time Frame	Country	Regression	Tax rate		
			coefficient	Adj-R ²	D-F test
1929 – 1980	US	$\ln\left(\frac{C}{M_2}\right) = \beta_0 + \beta_1 \ln(T) + \beta_2 \ln\left(\frac{WS}{NI}\right) + \beta_3 \ln R + \beta_4 \ln(Y) + \mu$	0.361** ⁷	0.89	Unit root
2002 – 2009	Euro Zone	$\Delta \ln\left(\frac{M_1}{M_3}\right) = \beta_0 + \beta_1 \Delta \ln(1+T_n)_t + \beta_2 \Delta \ln(1+GT)_t +$ $+ \beta_3 \Delta \ln\left(\frac{WS}{Y}\right)_t + \beta_4 \Delta \ln R_t + \beta_5 \Delta \ln\left(\frac{Y}{N}\right)_t + \beta_6 \Delta \ln\left(\frac{D}{C}\right) + \mu_t$	T~0.069 GT~0.0007	0.54	No unit root
1929 – 1980	US	$\Delta \ln\left(\frac{C}{M_2}\right) = \beta_0 + \beta_1 \Delta \ln(T) + \beta_2 \Delta \ln\left(\frac{WS}{NI}\right) + \beta_3 \Delta \ln R + \beta_4 \Delta \ln(Y) + \mu$	0.315**	0.54	No unit root
1929 – 2006	US	$\Delta \ln\left(\frac{C}{M_2}\right) = \beta_0 + \beta_1 \Delta \ln(T) + \beta_2 \Delta \ln\left(\frac{WS}{NI}\right) + \beta_3 \Delta \ln R + \beta_4 \Delta \ln(Y) + \mu$	0.224**	0.42	No unit root

Source: Made by the authors using monthly data collected on the Euro zone from 2002 - 200, yearly data provided by Tanzi (1980) and an extended panel data on the US from 1929 – 2006, see appendix 2 on a detailed description of the data and the data collection.

⁷ The sign ** means significant on a 5% level. When there is no sign, results are insignificant.

Appendix 4: Results of the regressions done using the variables listed in Table 2

Dependent	(1) Domestic C/M2	(2) Domestic C/M2	(3) Domestic C/M2	(4) Domestic C/M2	(5) Domestic C/M2	(6) Domestic C/M2	(7) Domestic C/M2	(8) Domestic C/M2	(9) Domestic C/M2
Y	-0.4363*** (0.082)	-0.4422*** (0.082)	-0.4361*** (0.083)	-0.4277*** (0.082)	-0.8968*** (0.175)	-0.8605*** (0.169)	-0.8901*** (0.167)	-0.8524*** (0.163)	-0.4727*** (0.082)
R	0.0005 (0.021)	-0.0087 (0.023)	-0.0006 (0.025)	-0.0029 (0.022)	-0.0019 (0.023)	0.0000 (0.022)	-0.0037 (0.023)	-0.0013 (0.021)	0.0126 (0.022)
WS/NI	-0.3788 (0.330)	-0.4293 (0.334)	-0.3817 (0.337)	-0.3206 (0.337)	-0.5302 (0.619)	-0.4151 (0.568)	-0.5799 (0.603)	-0.4405 (0.554)	-0.3948 (0.319)
Unemployment		-0.0384 (0.039)							
Tax rate			0.0116 (0.134)						
Government share				-0.1469 (0.160)					
Police expenditures					-0.3305 (0.446)				
Judicial expenditures						-0.3631 (0.276)			
Police exp p/c							-0.3973 (0.362)		
Judicial exp p/c								-0.4108 (0.253)	
Total crime rate									-0.1716* (0.096)
Constant	0.0146** (0.007)	0.0148** (0.007)	0.0145** (0.007)	0.0130* (0.007)	0.0770** (0.030)	0.0817*** (0.022)	0.0768*** (0.021)	0.0805*** (0.018)	0.0213*** (0.007)
Observations	37	37	37	37	20	20	20	20	37
R-squared	0.613	0.624	0.613	0.622	0.717	0.737	0.728	0.751	0.648
Adjusted R-squared	0.577	0.577	0.564	0.575	0.642	0.667	0.656	0.684	0.604

*The upper number in each cell is the applicable coefficient, the number below, between brackets, is the corresponding standard deviation, * indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level.*

Dependent	(10) Domestic C/M2	(11) Domestic C/M2	(12) Domestic C/M2	(13) Domestic C/M2	(14) Domestic C/M2	(15) Domestic C/M2	(16) Domestic C/M2	(17) Domestic C/M2	(18) Domestic C/M2
Y	-0.4765*** (0.082)	-0.4495*** (0.080)	-0.4692*** (0.078)	-0.4720*** (0.084)	-0.4427*** (0.082)	-0.4723*** (0.082)	-0.4285*** (0.085)	-0.4761*** (0.085)	-0.4353*** (0.083)
R	0.0126 (0.022)	0.0082 (0.021)	0.0131 (0.021)	0.0106 (0.022)	0.0046 (0.022)	0.0125 (0.022)	-0.0019 (0.023)	0.0017 (0.021)	0.0024 (0.022)
WS/NI	-0.4021 (0.318)	-0.3565 (0.323)	-0.3688 (0.310)	-0.4252 (0.326)	-0.3310 (0.333)	-0.3965 (0.320)	-0.3696 (0.335)	-0.5302 (0.341)	-0.3568 (0.338)
Total crime rate p/c	-0.1778* (0.095)								
Robberies		-0.0893 (0.056)							
Burglaries			-0.1749** (0.075)						
Larceny thefts				-0.1394 (0.098)					
Vehicle thefts					-0.0864 (0.085)				
Property crimes						-0.1669* (0.096)			
Elementary <5 yrs							-0.0441 (0.124)		
Elementary white								0.3130 (0.217)	
Elementary black									-0.0291 (0.113)
Constant	0.0197*** (0.007)	0.0184** (0.007)	0.0194*** (0.007)	0.0206** (0.008)	0.0175** (0.007)	0.0209*** (0.007)	0.0130 (0.008)	0.0244** (0.009)	0.0141 (0.008)
Observations	37	37	37	37	37	37	37	37	36
R-squared	0.651	0.641	0.669	0.636	0.625	0.646	0.614	0.636	0.618
Adjusted R-squared	0.607	0.596	0.627	0.590	0.578	0.602	0.566	0.591	0.569

The upper number in each cell is the applicable coefficient, the number below, between brackets, is the corresponding standard deviation, * indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level.

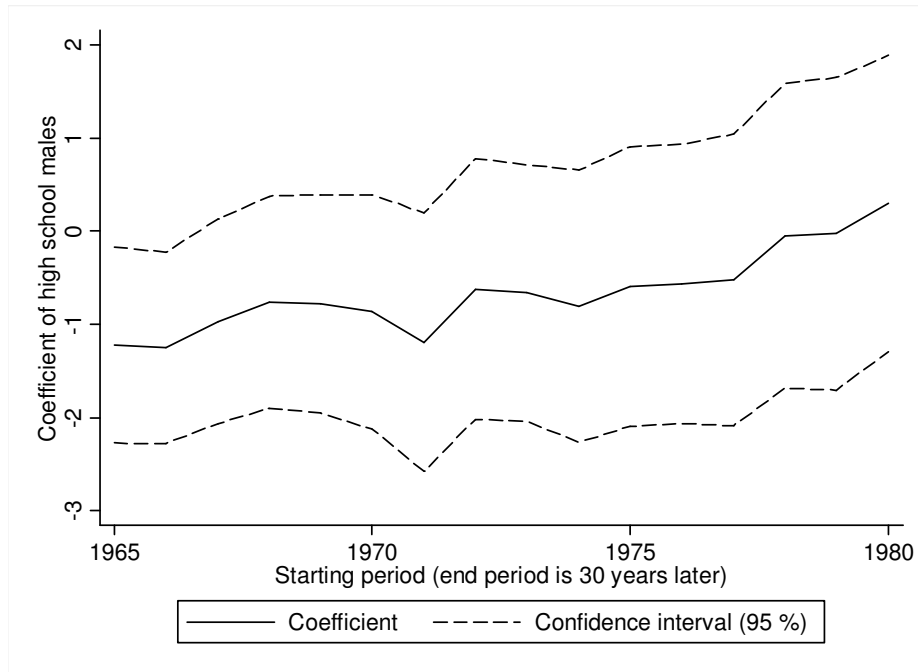
Dependent	(19) Domestic C/M2	(20) Domestic C/M2	(21) Domestic C/M2	(22) Domestic C/M2	(23) Domestic C/M2	(24) Domestic C/M2	(25) Domestic C/M2	(26) Domestic C/M2
Y	-0.4446*** (0.084)	-0.4277*** (0.083)	-0.4520*** (0.086)	-0.4640*** (0.086)	-0.4342*** (0.085)	-0.4351*** (0.082)	-0.4607*** (0.081)	-0.4417*** (0.082)
R	0.0031 (0.022)	-0.0038 (0.023)	-0.0018 (0.022)	0.0080 (0.022)	0.0001 (0.022)	-0.0055 (0.023)	0.0098 (0.022)	0.0036 (0.022)
WS/NI	-0.3858 (0.334)	-0.4008 (0.334)	-0.4495 (0.352)	-0.4264 (0.332)	-0.3758 (0.336)	-0.3829 (0.334)	-0.4160 (0.322)	-0.3794 (0.332)
Elementary male	0.0883 (0.177)							
Elementary female		-0.1404 (0.216)						
Elementary male white			0.0929 (0.151)					
Elementary female white				0.2177 (0.206)				
Elementary male black					0.0085 (0.082)			
Elementary female black						0.0806 (0.091)		
High school finished							-0.9136 (0.541)	
High school white								-0.1416 (0.191)
Constant	0.0177* (0.009)	0.0104 (0.009)	0.0178** (0.008)	0.0213** (0.009)	0.0149** (0.007)	0.0177** (0.007)	0.0282*** (0.010)	0.0171** (0.007)
Observations	37	37	37	37	37	36	37	37
R-squared	0.616	0.618	0.617	0.626	0.613	0.627	0.644	0.619
Adjusted R-squared	0.567	0.570	0.569	0.579	0.564	0.579	0.600	0.571

*The upper number in each cell is the applicable coefficient, the number below, between brackets, is the corresponding standard deviation, * indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level.*

Dependent	(27) Domestic C/M2	(28) Domestic C/M2	(29) Domestic C/M2	(30) Domestic C/M2	(31) Domestic C/M2	(32) Domestic C/M2	(33) Domestic C/M2	(34) Domestic C/M2
Y	-0.4358*** (0.082)	-0.4597*** (0.079)	-0.4592*** (0.081)	-0.4596*** (0.084)	-0.4390*** (0.083)	-0.4314*** (0.080)	-0.4364*** (0.083)	-0.4252*** (0.083)
R	0.0092 (0.023)	0.0102 (0.021)	0.0088 (0.022)	0.0081 (0.022)	0.0025 (0.022)	0.0126 (0.022)	0.0038 (0.023)	0.0069 (0.022)
WS/NI	-0.3011 (0.339)	-0.3884 (0.315)	-0.4364 (0.325)	-0.4289 (0.331)	-0.3755 (0.333)	-0.2570 (0.330)	-0.3503 (0.340)	-0.2765 (0.342)
High school black	-0.2844 (0.290)							
High school male		-1.0041** (0.492)						
High school female			-0.8903 (0.568)					
High school female white				-0.7507 (0.651)				
High school male white					-0.0557 (0.101)			
High school male black						-0.3949 (0.242)		
High school female black							-0.0807 (0.258)	
Income inequality GINI								0.4848 (0.482)
Constant	0.0241** (0.011)	0.0297*** (0.010)	0.0275** (0.010)	0.0266** (0.012)	0.0157** (0.007)	0.0275** (0.010)	0.0178* (0.010)	0.0139* (0.007)
Observations	36	37	37	37	37	37	36	35
R-squared	0.629	0.657	0.640	0.628	0.616	0.642	0.619	0.636
Adjusted R-squared	0.581	0.614	0.595	0.581	0.568	0.598	0.570	0.587

*The upper number in each cell is the applicable coefficient, the number below, between brackets, is the corresponding standard deviation, * indicates significance at the 10% level, ** indicates significance at the 5% level, *** indicates significance at the 1% level.*

Time robustness of high school completion male



Source: Made by the authors using regression (5) on the period 1965-2002. One should read this figure as follows: The straight line shows how the coefficient of high school males develops over time with 30 year periods (the first observation is 1965-1995, the next observation is the period 1966-1996 etc.) the dashed lines above and under the coefficient line show the confidence interval of the coefficient on a 5% significance level. This means that when zero lies within the confidence interval (like happens for the first time in the period of 1967-1997) the coefficient is not significant different from zero at the 5% significance level.