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Size and Development of the Shadow Economy and of Do-it-Yourself Activities: The Case of Germany

by

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Abstract:

This paper presents the first MIMIC (multiple indicator multiple causes) model estimate of the size and development of the shadow economy and of do-it-yourself (DIY) activities in Germany from 1970 to 2005. By 2005, they reached a level of about 17% and 4.94%. While the shadow economy has regularly increased over the years, DIY activities – though quite sizeable – have remained more or less constant since the early 1990s. The driving forces for the shadow economy are regulation and tax burden whereas for DIY activities, the level of unemployment is the main factor.

JEL-Classification: O17; O5; D78; H2, H11, H 26

Keywords: Shadow economy, Do-it-yourself activities, Tax burden, Regulation, Domestic currency in circulation, Unemployment, MIMIC models

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1. Introduction

Shadow economic and DIY activities are a fact of life around the world. Do-it-yourself activities are generally seen as something positive and creative while the shadow economy is treated differently – that is, in a much more negative way. Most societies attempt to control the shadow economy through punishment or by relying on "official" economic growth or on education. Very often, shadow economic and DIY activities are seen as substitutes (e.g. if it is too risky to demand shadow economic activities, I only undertake DIY ones) or as complements (since I am capable of doing certain things, and if I do it myself it goes more quickly, I do not need to demand all services in the shadow economy.) Both types of activity are seen as a way to mitigate financial constraints (I can save money if the official economy is too expensive). The magnitudes at which shadow economic and DIY activities occur are not only important for academics, but also for politicians and the public. Gathering such statistics requires accurate information about who is engaged in the shadow economy and DIY activities and the frequencies with which these activities occur. It is difficult to obtain such information because individuals engaged in shadow economic activities do not readily volunteer details about these activities. Measuring DIY activities, however, is no less challenging as this is also a neglected area and has not been officially measured so far.[4]

Consequently, the estimation of the shadow economy and of DIY activities becomes a scientific passion to know the unknown. Although quite a large amount of literature on particular aspects of the shadow economy as well as a

[4] First, pioneering measurements of DIY activities have been undertaken by Karmann (1990) where some elementary hypotheses on shadow economic and DIY activities causes were derived, and a simple empirical demand-sided analysis was undertaken.

comprehensive survey exist, the subject remains controversial.[5] Moreover, the authors are not aware of any studies which try to simultaneously estimate both the shadow economy and DIY activities. The major goal of this paper, therefore, is to provide such an estimation as well as to track the development of the shadow economy and DIY activities in Germany from 1970 to 2005. Further goals are to consider the impact of German reunification on shadow economic and DIY activities, to employ a proper estimate of domestic currency in circulation within Germany as an indicator variable for the shadow economy, and finally, to examine how sensitive these results are and how robust the (latent) estimation procedure – in this case the MIMIC model – is.

Chapter 2 provides a short review of hitherto existing estimates of the German shadow economy. It also defines the shadow economy and DIY activities and proposes theoretical considerations as to why people turn to shadow economic and DIY activities. Chapter 3 presents the empirical results, starting with the causal and indicator variables, followed by the econometric estimation result of the MIMIC models and, finally, the size and development of the shadow economy and of DIY activities in Germany. Chapter 4 summarizes and draws some policy conclusions. In the appendices, sources of the data used are provided, and some further robustness test results and estimations are presented.

[5] See Frey and Pommerehne (1984), Thomas (1992), Loyaza (1996), Pozo (1996), Lippert and Walker (1997), Schneider (1994a,b, 1997, 1998a,b, 2003, 2005), Johnson *et al.* (1997, 1998a,b), Belev (2003), Gërxhani (2004), and Pedersen (2003). For surveys of evidence, see Schneider and Enste (2000, 2002), Schneider (2003) and Alm *et al.* (2004).

2. Some Theoretical Considerations

2.1. Short Literature Review

Existing estimates of the German shadow economy (measured in percentage of official GDP) are shown in Table 2.1.[6] The oldest estimate uses the survey method of the Institute for Demoscopy (IfD) in Allensbach, Germany and shows that the shadow economy was 3.6% of official GDP in 1974. In a much later study, Feld and Larsen (2005) undertook an extensive research project using the survey method to estimate shadow economic activities in the years 2001 and 2004.[7] Using the officially paid wage rate, they concluded that these activities reached 4.1% in 2001 and 3.1% in 2004. Using the (much lower) shadow economy wage rate, however, these estimates shrink to 1.3% and 1.0%, respectively. If we look at the discrepancy method, for which we have estimates from 1970 to 1980, the German shadow economy is much larger: using the discrepancy between expenditure and income, we get approximately 11% for the 1970s, and using the discrepancy between official and actual employment, roughly 30%. The physical input methods where estimates for the 1980s are available deliver values of around 15% for the second half of that decade. The (monetary) transaction approach developed by Feige (1996) places the shadow economy at 30% between 1980 and 1985. Yet another monetary approach, the currency demand approach – the first person to undertake an estimation for Germany was Kirchgässner (1983, 1984) – provides values of 3.1% (1970) and 10.1% (1980). Kirchgässner's values are quite similar to the ones obtained by Schneider and Enste (2000, 2002), who also used a currency demand approach to value the size of the shadow economy at 4.5% in 1970 and 14.7% in 2000.

[6] A similar table can be found in Feld *et al*. (2007).

[7] In our paper there is no extensive discussion about the various methods to estimate the size and development of the shadow economy, also we do not discuss the strength and weaknesses of each method. Compare for this Schneider and Enste (2000), Schneider (2005), Feld and Larsen (2005), Pedersen (2003), and Giles (1999a,b,c).

Finally, if we look at latent (DY)MIMIC estimation procedures, the first ones being conducted by Frey and Weck-Hannemann (1984), and later, Schneider and others followed for Germany, again, the estimations for the 1970s are quite similar. Furthermore, Schneider's estimates using a DYMIMIC approach (Schneider (2005, 2007)) are close to those of the currency demand approach.

Thus, we can see that different estimation procedures produce different results. It is safe to say that the figures produced by the transaction and the discrepancy approaches are rather unrealistically large: the size of the shadow economy at almost one-third of official GDP in the mid-1980s is most likely an overestimate. The figures obtained using the currency demand and hidden variable (latent) approaches, on the other hand, are relatively close together and much lower than those produced by other methods (i.e. the discrepancy or transaction approaches). This similarity is not surprising given the fact that the estimates of the shadow economy using the latent (MIMIC) approach were measured by taking point estimates from the currency demand approach. Still, what is lacking is a consistent estimate of the shadow economy and of DIY activities. This is the goal of our paper.

Table 2.1

The Size of the Shadow Economy in Germany According to Different Methods (in Percentage of Official GDP)

Method	Shadow economy (in percentage of official GDP) in:								Source
	1970	1975	1980	1985	1990	1995	2000	2005	
Survey	-	3.6 [1)]	-	-	-	-	-	-	IfD Allensbach (1975)
	-	-	-	-	-	-	4.1 [2)]	3.1 [2)]	Feld and Larsen (2005)
	-	-	-	-	-	-	1.3 [3)]	1.0 [3)]	
Discrepancy between expenditure and income	11.0	10.2	13.4	-	-	-	-	-	Lippert and Walker (1997)
Discrepancy between official and actual employment	23.0	38.5	34.0	-	-	-	-	-	Langfeldt (1983)
Physical input method	-	-	-	14.5	14.6	-	-	-	Feld and Larsen (2005)
Transactions approach	17.2	22.3	29.3	31.4	-	-	-	-	
Currency demand approach	3.1	6.0	10.3	-	-	-	-	-	Kirchgässner (1983)
	12.1	11.8	12.6	-	-	-	-	-	Langfeldt (1983, 1984)
	4.5	7.8	9.2	11.3	11.8	12.5	14.7	-	Schneider and Enste (2000)
Latent ((DY)MIMIC) approach	5.8	6.1	8.2	-	-	-	-	-	Frey and Weck (1983)
	-	-	9.4	10.1	11.4	15.1	16.3	-	Pickardt and Pons (2006)
	4.2	5.8	10.8	11.2	12.2	13.9	16.0	15.4	Schneider (2005, 2007)
Soft modelling	-	8.3 [4)]	-	-	-	-	-	-	Weck-Hannemann (1983)

1) 1974.

2) 2001 and 2004; calculated using wages in the official economy.

3) 2001 and 2004; calculated using actual “black” hourly wages paid.

4) Average of 1974 and 1975.

2.2. Defining the Shadow Economy and DIY Activities

Most authors attempting to measure the shadow economy face the difficulty of how to define it. One commonly used working definition is all currently unregistered economic activities that contribute to the officially calculated (observed) Gross National Product.[8] Smith (1994, p. 18) defines it as, "market-based production of goods and services, whether legal or illegal that escapes detection in the official estimates of GDP". One of the broadest definitions includes "those economic activities and the income derived from them that circumvent government regulation, taxation or observation".[9] As these definitions still leave a lot of questions open, Table 2.2 is helpful for developing a reasonable consensus on the definition of the shadow economy.

[8] This definition is used for example, by Feige (1989, 1994), Schneider (1994a, 2003) and Frey and Pommerehne (1984). For early, demand-sided estimates of the shadow economy and DIY activities for Germany see Karmann (1990).

[9] This definition is taken from Dell'Anno (2003), Dell'Anno and Schneider (2003) and Feige (1989); see also Thomas (1999), Fleming *et al*. (2000).

Table 2.2

A Taxonomy of Types of Economic Activities[1)]

Type of activity	**Monetary transactions**		**Non-monetary transactions**	
Illegal activities	Trade in stolen goods, drug dealing and manufacturing, prostitution, gambling, smuggling, fraud, etc.		Barter of drugs, stolen goods, smuggling, etc., production or growing of drugs for own use, theft for own use.	
	Tax evasion	**Tax avoidance**	**Tax evasion**	**Tax avoidance**
Legal activities	Unreported income from self-employment, wages, salaries and assets from unreported work related to official/ lawful goods and services.	Employee discounts, fringe benefits.	Barter of official/lawfulg oods and services.	All do-it-yourself work and neighbourly help.

[1)] Structure of table taken from Lippert and Walker (1997, p. 5) with additional remarks.

From Table 2.2, it becomes clear that a broad definition of the shadow economy includes unreported income from otherwise official trade in goods and services, e.g. through monetary or barter transactions – and thus includes all economic activities that would generally be taxable were they reported to governmental (tax) authorities. In this paper, the following, more narrow definition of the shadow economy is used:[10] the shadow economy includes all market-based, lawful trade in goods and services that are deliberately concealed from public authorities for one of the following reasons:

(1) to avoid payment of income, value added or other taxes;

(2) to avoid payment of social security contributions;

[10] Compare also the excellent discussion on the definition of the shadow economy in Pedersen (2003, pp.13-19), who uses a similar one.

(3) to avoid having to meet certain legal labour market standards, such as minimum wages, maximum working hours, safety standards, etc.; or,
(4) to avoid compliance with certain administrative procedures, such as filling in statistical questionnaires or other administrative forms.

Similarly, DIY activities include all market-based goods and services which are produced do-it-yourself in order to avoid gross wage payments, including taxes and social security contributions, in the official economy or to avoid any net wage payments in the shadow economy. It is important to note, however, that the main difference between DIY and shadow economic activities is that the former are entirely legal.

This paper shall not deal with typical, underground criminal activities, such as burglary, robbery, drug dealing, etc., which are all illegal. Rather, this paper investigates neglected shadow economic and lawful DIY activities in order to estimate their size. The term hidden economy is always used when considering the combined sector of shadow and do-it-yourself activities.

2.3. Main Causes of Shadow Economic and DIY Activities

2.3.1. Tax and Social Security Contribution Burdens

Studies point to tax and social security burdens as one of the main reasons for the existence of the shadow economy.[11] Since taxes affect labour-leisure choices as well as stimulate labour supply in the shadow economy, the distortion of the overall tax burden is a major concern for economists. The greater the difference between the total cost of labour in the official economy and the after-tax

[11] See Thomas (1992); Lippert and Walker (1997); Schneider (1994a,b, 1997, 1998a,b, 2000, 2003); Johnson *et al.* (1998a,b,); Tanzi (1999); Giles (1999a); Mummert and Schneider (2002); Giles and Tedds (2002), Giles *et al.* (2002) and Dell'Anno (2003).

earnings from work is, the more incentive people have to avoid this difference by working in the shadow economy. The studies of Schneider (1994b, 2000) and Johnson *et al.* (1998a, 1998b) provide statistically significant empirical evidence of the influence of tax burdens on the shadow economy. The strong influence of indirect and direct taxation on the shadow economy is further demonstrated through the empirical results in Austria and the Scandinavian countries (Schneider (1986), (1994 a, b)). In contrast to shadow economic activities, the effect of tax burdens on DIY activities is more ambiguous as higher taxation may also drive up prices for do-it-yourself goods, thereby making do-it-yourself work more costly. This effect may countervail the distortion effect on official labour supply.

2.3.2. Intensity of Regulation

The intensity of regulation (often measured by the amount of laws and regulations, such as license requirements, or by the size of staff at regulatory agencies) is another important factor. An increase reduces the freedom (of choice) for individuals engaged in the official economy.[12] Examples would be labour market regulations, trade barriers, and labour restrictions on foreigners. Johnson *et al.* (1998b) find significant empirical evidence of the influence of (labour) market regulations on the shadow economy. The impact is also clearly described and theoretically derived in other studies, for example in the findings of the Deregulation Commission 1990/91 (Germany). Regulations lead to a substantial increase in labour costs in the official economy, but since most of these costs can be shifted onto employees they provide an incentive to work in the shadow economy – where they can be avoided.

[12] For a (social) psychological, theoretical foundation of this feature, see Brehm (1966, 1972), and for a (first) application to the shadow economy, see Pelzmann (1988).

2.3.3. Other Influential Factors

(1) Unemployment

Obviously, the higher the unemployment is, the higher the incentive to be engaged in DIY activities. Unemployed people have less money for purchasing goods and services and therefore a higher incentive to engage in DIY activities. Additionally, DIY activities may enhance the unemployed's self-esteem, thereby further stimulating DIY activities.

(2) Average gross hourly earnings

It is also apparent that the higher the average gross hourly earnings in the "official" small trade sector are, the higher the costs are for people who demand such services. Given that people have the ability to do these activities themselves, we postulate that higher average gross hourly earnings lead to an increase in the volume of DIY activities, *ceteris paribus*.

(3) Real disposable income

Since real disposable income is positively correlated to demand for goods and services in general, we hypothesize that the higher the real disposable income is, the greater the demand not only in the official but also in the unofficial economy is and hence the larger the shadow economy is.

2.3.4. Summarizing our Hypotheses

After defining the shadow economy and DIY activities and providing some theoretical considerations on why people work in the shadow economy or are

engaged in DIY activities, we would like to reiterate our hypotheses. Because it is not clear whether shadow economic and DIY activities can be treated as complements or substitutes – they may have both functions under different circumstances – we do not formulate any hypotheses about the interaction between these activities. Instead, we undertake the first (to our knowledge) proper attempt to simultaneously estimate the shadow economy and DIY activities according to the following hypotheses:

(1) An increase in tax and social security burdens increases shadow economic and DIY activities, *ceteris paribus*.
(2) The more the German economy is regulated, the greater the incentive is to work in the shadow economy, *ceteris paribus*.
(3) The higher the unemployment in Germany is, the more people engage in DIY activities, *ceteris paribus*.
(4) The higher the total wage cost in the official economy is, the more people undertake DIY activities, *ceteris paribus*.

2.4. Indicator Variables of Shadow Economic and DIY Activities

The MIMIC estimation procedure assumes that cause variables influence the shadow economy whereas indicator variables reflect shadow economic activities. In addition to the variables which contribute to the size and development of the shadow economy, we have four indicator variables that reflect shadow economic activities themselves.

The first indicator variable is the domestic currency in circulation, i.e. cash outside the banking system in the form of coins and banknotes that can be physically held in the hand. This amount of currency is typically used for day-to-day expenses but also for shadow economic activities.

Here, we formulate the following four hypotheses:

(5) The larger the shadow economy is, the more currency (measured in real currency) there is in circulation, *ceteris paribus*.

If the official real GDP growth rate is low, the incentive to engage in the shadow economy rises. In other words, the lower the level of official activity is, the fewer possibilities people have to earn more money or to obtain employment in the official economy. For this reason, we formulate the following hypothesis:

(6) The lower the growth rate of real GDP is, the larger the shadow economy is, *ceteris paribus*.

On the other hand, the reverse causation could also hold true, i.e. the higher the economic growth, the larger the shadow economy. One explanation is that if the official economy grows, the shadow economy may grow as well since favourable conditions for economic growth apply for both the official as well as the unofficial economy and especially since additional goods purchased (e.g. cars) in the official economy lead to a demand in maintenance and other services in the shadow economy.

The average hours worked per week in the official economy is also an important indicator for shadow economic activities. The more people work in the official economy, the less time they have to be engaged in the shadow economy. We therefore formulate the following hypothesis:

(7) The more people work – measured by the average hours worked per week – in the official economy, the smaller the shadow economy is, *ceteris paribus*.

Do-it-yourself activities are best reflected in the estimated real turnover in DIY stores. Thus, we formulate our last hypothesis:

(8) The greater the amount of DIY activities is, the higher the estimated real turnover in DIY stores is, *ceteris paribus*.

3. Empirical Results: the Hidden Economy in Germany

3.1. Data Sources

Our data cover the period 1970 to 2005 on an annual basis. All data except that on tax and social security contributions, on domestic currency in circulation, and on turnover in DIY stores are taken from the Federal Statistical Office of Germany. The latter were made available by A.C. Nielsen Company GmbH and cover 1978 to 2005. The estimated growth rates from 1970 to 1977 are used to predict the level of turnover in DIY stores for this period. For the approximation of tax and social security contribution burdens, we use public revenue data provided by the Organisation for Economic Co-operation and Development (OECD). The main components are income tax, value added and sales taxes, social security contributions, and payroll taxes.

Data on domestic currency in circulation are taken from the Deutsche Bundesbank. From the 1950s to 2001, DM-denominated currency in circulation outside the banking system greatly increased and cannot be examined on the basis of domestic transactions in the official and unofficial economies alone. One possible explanation is the rise in foreign demand for the Deutsche Mark during that time (Seitz, 1995). The bulk of foreign demand in the 1990s stemmed from Eastern and Southeast Europe after the breakdown of the Council

for Mutual Economic Assistance (COMECON) system. Unstable political circumstances in the early 1990s, the war in Kosovo, and the Bulgarian Financial Crisis of 1996/1997 increased foreign demand for the Deutsche Mark further. Given that we are interested in shadow economic and DIY activities in Germany only, it is essential to focus on domestic currency demand as an indicator variable for the shadow economy. For this reason, we exclude foreign demand for the Deutsche Mark from the total amount of currency in circulation (provided by the Deutsche Bundesbank) and instead use the methodology proposed by Seitz (1995) to assess domestic demand for currency in circulation. We then apply this methodology both to take German reunification into account and to adjust for the distortion in domestic currency in circulation during the second half of 2001 as a result of the public's preparation for the introduction of the Euro (in 2002). At that time, people substituted cash with demand deposits in order to avoid personally exchanging their Deutsche Mark for Euros (Deutsche Bundesbank, 2002). This triggered an enormous decrease in domestic currency in circulation which cannot be attributed to changes in shadow economic or DIY activities. The details of our estimation procedures are provided in subsections 5.2. and 5.3 of the Appendix, which also provides a complete list of data sources in Table 5.1.

Before proceeding, we shall test our data for stationarity. The results are discussed in the next subsection.

3.2. Unit Root Tests

Applying MIMIC models[13] with nonstationary time series may result in misleading estimates. To overcome this problem and to avoid spurious regressions, we conduct the Phillips and Perron (PP) unit root test (Phillips and

[13] One of the first studies using this approach over time was that of Aigner *et al*. (1988), who estimated the shadow economy of the United States.

Perron, 1988) to check for the presence of a unit root in a particular times series. For the series in levels, an intercept and a time trend are included. The Schmidt-Phillips unit root test as proposed by Schmidt and Phillips (1992) is employed to cross check the presence of a unit root. Table 5.2 in the Appendix displays the results. In all cases, except for the variable average gross hourly earnings (Wages) – where both tests show inconsistent results – we cannot reject the null hypothesis of a unit root at the 5% significance level. As a result, we treat the variables as I(1) and differenced them once to achieve stationarity. In this case, we employ the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test (Kwiatkowski *et al*., 1992) to cross check the results from the PP test. For most variables, we cannot reject the null hypothesis of stationarity at the 5% significance level. Only for the variables Income and Reg are the values of the test statistic slightly greater than the 5% critical value. As the time series for the turnover in DIY stores (Tdiy) remains nonstationary even after taking first differences, the approach suggested by Schwert (1987) is employed to detrend the time series of the variable Tdiy successfully. Because of the limited sample size, the lag order is set to two. The findings from our unit root tests are displayed in Table 3.1.

Table 3.1

Results of Unit Root Tests for the Variables Used

	PP test		**KPSS test**	
Variable	Test statistic	Lag length	Test statistic	Lag length
Curr	-3.5121	6	0.3840	2
Grgdp	-4.0100	1	0.1869	1
Hours	-3.0728	1	0.1358	4
Income	-4.5613	2	0.5149	3
Inf	-5.2178	6	0.0562	3
Reg	-4.7745	0	0.6024	2
Tdiy (first difference)	-1.4123	0	0.4460	2
Tdiy (detrended)	-5.3301	2	0.0687	1
Tbur	-3.6901	0	0.4460	2
Unemp	-3.5503	11	0.3979	2
Wages	-4.1005	2	0.4521	4

The order of the autoregressive correction for both tests was chosen using the Bartlett kernel estimator and the Newey-West (1994) data-based automatic bandwidth parameter method. All regressions include an intercept but no time trend. The critical values for the PP test – taken from MacKinnon (1996) – are: -3.64 (1% level), -2.95 (5% level), and -2.61 (10% level). The LM statistics critical values of the KPSS test – taken from Kwiatkowski *et al*. (1992) – are: 0.7390 (1% level), 0.4630 (5% level), and 0.3470 (10% level).

Table 3.2 presents a detailed description of the variables ultimately used in the MIMIC models as well as all data transformations carried out to achieve stationarity for the respective variables.

Table 3.2

Variables Used in the MIMIC Model

Variable used	Description of the variable used
Indicator variables	
Curr	First difference of the natural logarithm of the level of real domestic currency in circulation as estimated in section 5.2.
Grgdp	Growth rate of real GDP.
Hours	First difference of the natural logarithm of the average hours worked per week.
Tdiy	Detrended natural logarithm of the real turnover in do-it-yourself stores as explained in section 5.3.
Causes variables	
Dummy	One for the years 1991 and 1992 to cover impulse effects in the differenced variables as a result of German reunification, null else.
Income	First difference of the natural logarithm of the per capita real disposable income in Germany.
Inf	First difference of the natural logarithm of the ratio of current year's CPI to previous year's CPI.
Reg	First difference of the ratio of the number of people employed in public service (excluding people employed by railways and the postal service, which were previously state-run) to total population.
Tbur	First difference of the per capita public revenues for Germany.
Unemp	First difference of the natural logarithm of the number of unemployed people.
Wages	First difference of the natural logarithm of the average gross hourly earnings of male workers in the small trade sector.

As a result of data transformation, the model is estimated in first differences and thus provides estimations of latent variables in first differences only. Consequently, we must integrate the resulting time series in differences to obtain the index series for the shadow economy (S), DIY and the hidden economy spectrum (H).

3.3. MIMIC Models

Our estimation of the shadow economy and of DIY activities is based on two alternative model specifications. The first (S-DIY) model considers shadow economic and DIY activities as two distinct latent variables that will be estimated simultaneously in a MIMIC model. Following our earlier hypotheses,

we use the variables measuring both tax and social security contribution burdens as well as the intensity of regulation as the main elements to describe shadow economic activities. Do-it-yourself activities, however, are best explained through unemployment, tax and social security contribution burdens, and average gross hourly earnings. Despite the ambiguous theoretical effect of higher inflation on the shadow economy and on DIY activities, we consider inflation as a causal variable for the latent variables in our MIMIC models. Since inflationary pressure lowers nominal tax burdens, we expect increasing inflation to have a negative impact on the amount of both shadow economic and DIY activities. Furthermore, we use a dummy variable (Dummy) to control for structural changes of the German economy and impulse effects on the data as a result of German reunification in 1990. The conceptual diagram of the S-DIY model is shown in Figure 3.1.

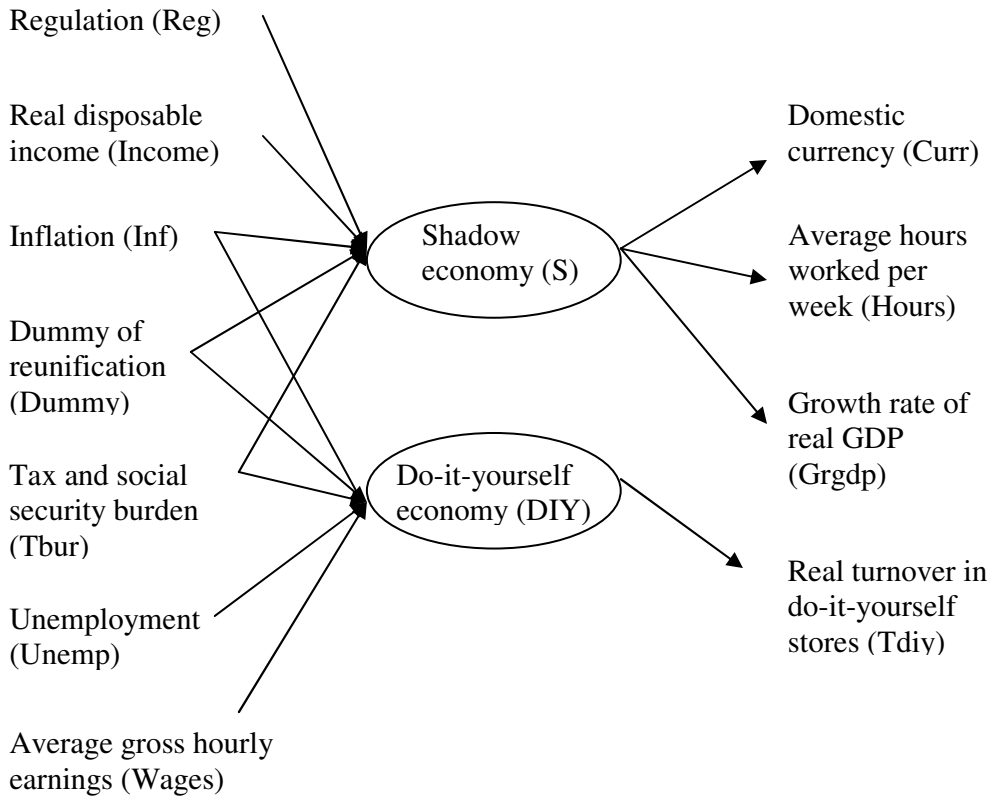

Fig. 3.1 *Conceptual Diagram of the S-DIY MIMIC Model*

To confirm the S-DIY model, we estimate a second (H-DIY) model specification. In this H-DIY model, the hidden economy spectrum, H, is estimated using the same causal variables used for the estimation of the shadow economy in the S-DIY model. As illustrated in Figure 3.2, DIY activities are then determined by the causal link between latent variables and are measured as a percentage of the overall hidden economy. The size of the shadow economy is derived by subtracting DIY activities from the hidden economy.

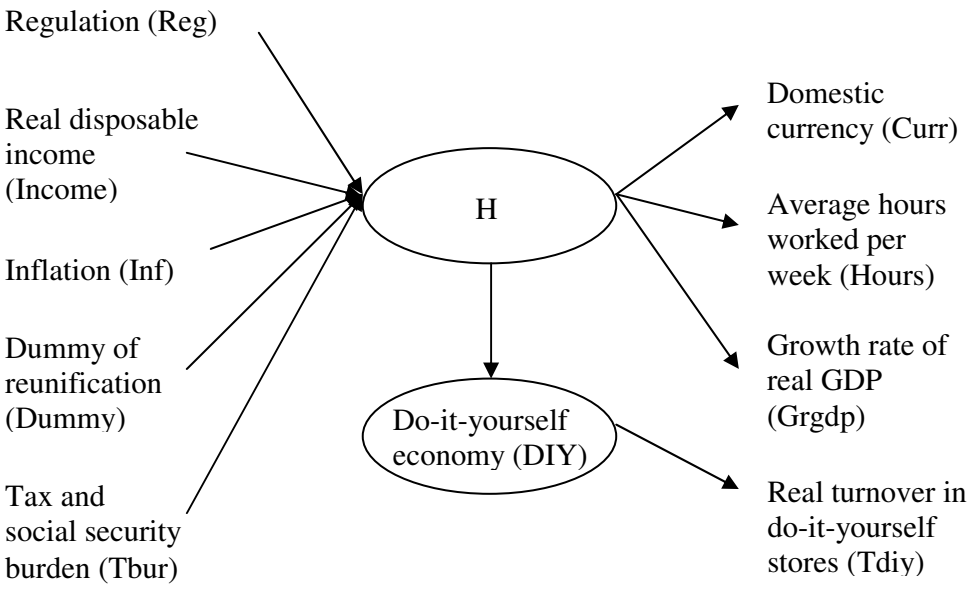

Fig. 3.2 *Conceptual Diagram of the H-DIY MIMIC Model*

Since S is a decisive part of H, all indicator variables used for S must also be considered for H. Hence, the same set of indicator variables is employed in both model specifications.

As indicators of the shadow economy, we use the growth rate of real GDP (Grgdp), the estimated domestic currency in circulation (Curr), and the average hours worked per week (Hours). For the latent DIY activities, we use turnover in

DIY stores in Germany (Tdiy) as a particularly suitable indicator. The results of both MIMIC model estimations, applying the maximum likelihood estimator for the S-DIY model as well as for the H-DIY model are shown in Table 3.3. For each model specification, the first column shows the parameter estimates for both causal as well as indicator variables for S and H. The parameter estimates relating to DIY activities are displayed in the second column. The last two rows in Table 3.3 refer to the causal link between H and DIY in the H-DIY model.

The following summarizes our findings from the estimation of the presented MIMIC models and addresses our proposed hypotheses.

(1) The intensity of regulation is always highly statistically significant and is positively related to S and H, having the expected sign.
(2) Tax and social security contribution burdens are statistically significant different from zero for S as well as for H and are, as expected, positively related to both latent variables. We cannot confirm that the tax burden is a driving factor for the public to engage in DIY activities.
(3) In both model specifications, the variable Income, which measures per capita real disposable income, is highly statistically significant and positively related to S and H. One possible explanation is that the higher the disposable income of households, the higher the demand for goods and services. Demand rises not only in the official economy but also, in part, in the shadow economy, leading to a higher observed level of shadow economic activity. This implies that both sectors are complementary to each other.
(4) The variable Inf is statistically different from zero for DIY activities only; that is, the inflation rate influences DIY activities and has a negative sign. As was previously mentioned, it is not clear from the literature whether inflation appears with a positive or negative sign. With a negative sign, a possible interpretation is that the higher the inflation rate – which makes raw materials

for DIY activities more expensive – the fewer activities individuals perform, leading to a lower level of the latent variable DIY. The negative, though insignificant, influence of inflation on shadow activities, given all other causal factors, may be seen as contributing to a reduction in real tax burdens, thereby reducing incentives to avoid taxation.

(5) The dummy variable which measures the impact of German reunification in 1990 is positively related to both shadow economic and to DIY activities, as well as to the hidden economy spectrum. The variable is always highly statistically significant, has the expected sign, and reflects the catching up process after the reunification of both economies.

(6) The unemployment level is an important factor in DIY activities. The variable, Unemp, is positively related to the respective latent variable and has the expected sign.

(7) In our MIMIC models, hourly earnings in the small trade sector, measured by the variable Wages, do not influence do-it-yourself activities since the relationship between the variable Wages and DIY is not statistically different from zero. Nevertheless, the parameter estimate has the expected sign, showing that higher wages lower the demand for small trade services and hence raise the incentives for the public to engage in DIY activities.

With regard to the indicator variables, we fix one indicator for each latent variable. For the shadow economy, we choose the variable Curr. For the latent variable indicating DIY activities, we opt for the variable Tdiy. For the two remaining indicators, we obtain the following results:

(8) The estimated coefficient on the Grgdp indicator variable is statistically different from zero and hence suggests a positive relationship between the shadow economy and the growth rate of real GDP.

(9) For the second indicator variable, Hours, we cannot confirm that the size of the shadow economy affects the average hours worked per week. The estimated coefficient is always statistically insignificant at any reasonable significance level.

Table 3.3

MIMIC Model Results and Parameter Estimates

	S-DIY model		**H-DIY model**	
	S	DIY	H	DIY
Indicator variables				
Curr	1.00		1.00	
Grgdp	0.25***		0.22***	
	(3.32)		(3.22)	
Hours	-0.02		-0.01	
	(-1.32)		(-1.10)	
Tdiy		2.00		2.00
Causes variables				
Reg	11.98**		11.24**	
	(2.54)		(2.51)	
Income	1.38***		1.43***	
	(3.34)		(3.54)	
Inf	-0.32	-0.53**	-0.93	
	(-0.50)	(-2.44)	(-1.44)	
Dummy	0.10**	0.05***	0.13***	
	(2.50)	(4.18)	(3.29)	
Tbur	0.11**	-0.01	0.09**	
	(2.37)	(-0.37)	(2.07)	
Unemp		0.03**		
		(2.14)		
Wages		0.15		
		(0.85)		
Latent Variable				
H				0.13**
				(2.05)

T-statistics appear in parenthesis. * = significance at 10% level, ** = significance at 5 % level, *** = significance at 1% level.

In order to estimate not only the relative size but also the levels of our latent variables, it is necessary to fix a scale for each latent variable used. A convenient albeit somewhat arbitrary way is to set the coefficient of one

indicator variable of the measurement model to non-zero, thereby simplifying examination of the relative magnitude of the other indicator variables (Giles and Tedds, 2002, p. 109). We set the coefficient of the variable Curr to one since the size of the shadow economy is measured in monetary units. Because we are dealing with two latent variables simultaneously, it is also necessary to fix the other unobserved variable, DIY. Our decision to set the coefficient of the indicator variable Tdiy to two is based on the following theoretical consideration:[14] capital productivity measures the ratio of output to capital input, indicating the value added in a specific business sector. Since we employ the capital input of DIY activities, i.e. turnover in DIY stores, as an indicator for the unobserved variable DIY, i.e. the output, the use of capital productivity as a fixed parameter seems to be appropriate. Assuming that the value added in the construction business is nearly equal to that of DIY activities, we choose an approximate value of capital productivity for the construction business in 1991 (the approximate mid-point of our observation period). According to the Federal Statistical Office of Germany, capital productivity in the construction business was 1.89 in 1991.

As Table 3.3 also shows, all variables except Hours and Tbur are significant at the 5% significance level for both S as well as for H. With regard to the latent variable DIY, only the variable Tbur is not statistically significant. We also estimate both model specifications but exclude the insignificant variables. The parameter estimates, nevertheless, remain stable, as can be seen from the last column of Tables 5.3 and 5.4 in the Appendix. In addition, we employ robustness checks by varying the observation period. Again, parameter estimates remain rather stable (see Table 5.3 and Table 5.4). The test statistics representing the overall fit of the S-DIY and H-DIY models and the

[14] For similar arguments see also Karmann (1990).

parsimonious model specifications excluding the insignificant variables are displayed in Table 3.4.

Table 3.4

Summary Statistics of the Estimated MIMIC Model

	Full model		**Parsimonious model**	
	S-DIY	**H-DIY**	**S-DIY**	**H-DIY**
Degrees of freedom	50	33	34	19
Chi-square	34.87	30.19	24.92	11.02
(p-Value)	(0.9486)	(0.6077)	(0.8718)	(0.9231)
Root mean squared error of approximation (RMSEA)	0.0000	0.0000	0.0000	0.0000
P-value for test of close fit (RMSEA < 0.05)	0.9800	0.7300	0.9800	0.9500
Root mean square residual (RMR)	0.0003	0.0005	0.0003	0.0006
Standardized RMR	0.087	0.12	0.087	0.095
Goodness of fit index (GFI)	0.85	0.84	0.84	0.92
Adjusted goodness of fit index (AGFI)	0.80	0.78	0.79	0.88
Parsimony goodness of fit index (PGFI)	0.64	0.62	0.64	0.62

Overall, the global goodness of fit statistics of the various model specifications show satisfactory statistical properties. Nevertheless, for the S-DIY model, the statistics of the full model indicate a slightly closer fit compared to the parsimonious one whereas for the H-DIY model, the reverse is true. To assure comparability between the estimates of both the S-DIY and the H-DIY model, we always use the full model specifications to predict the size of shadow economic and DIY activities in Germany from 1970 to 2005. We refrain from displaying the global goodness of fit statistics for robustness checks with variations in the observation period since they do not differ much from those of the full models.

3.4. Size of the Shadow Economy and of DIY Activities

One difficulty of MIMIC model estimations is that the obtained ordinal series needs to be converted into a cardinal series. In the literature, this is usually done by calibration using an absolute level of the estimate at a particular time within an observation period. Since we employ the first differences of the variables in the MIMIC models, the latent variable is estimated under the same transformation. In order to obtain the actual values of the shadow economy and DIY activities as a percentage of official GDP, an *a priori* known value is required. This can be done by using the average of estimates from a number of other studies (Schneider and Enste, 2000). One can also identify such a benchmark, however, by estimating a cardinal series through some other approach, for example, the cash demand approach (Giles and Tedds, 2002). In this paper, we refer to the estimate obtained by Karmann (1990) for the size of DIY activities in Germany since it is (to our knowledge) the only estimate that exists. To be consistent with the results obtained in this study, we also take the estimate for the size of the shadow economy from Karmann (1990). Thus, we apply the shadow economy estimate of 8.5% and the DIY estimate of 4.4% to scale up our ordinal series. Both benchmark point estimates refer to 1983. The complete cardinal series we identify are shown in Figures 3.3-3.5. Figure 3.3 plots the size and development of the shadow economy according to the S-DIY model. It shows a remarkable increase in the shadow economy over the past 25 years, reaching 17.40% of official GDP in 2005. German reunification in 1990 triggered a steep rise in the shadow economy during the reconstruction period that followed. After East Germany caught up to West Germany's behavioural patterns, growth in the shadow economy slowed down considerably to the current level of around 17%.

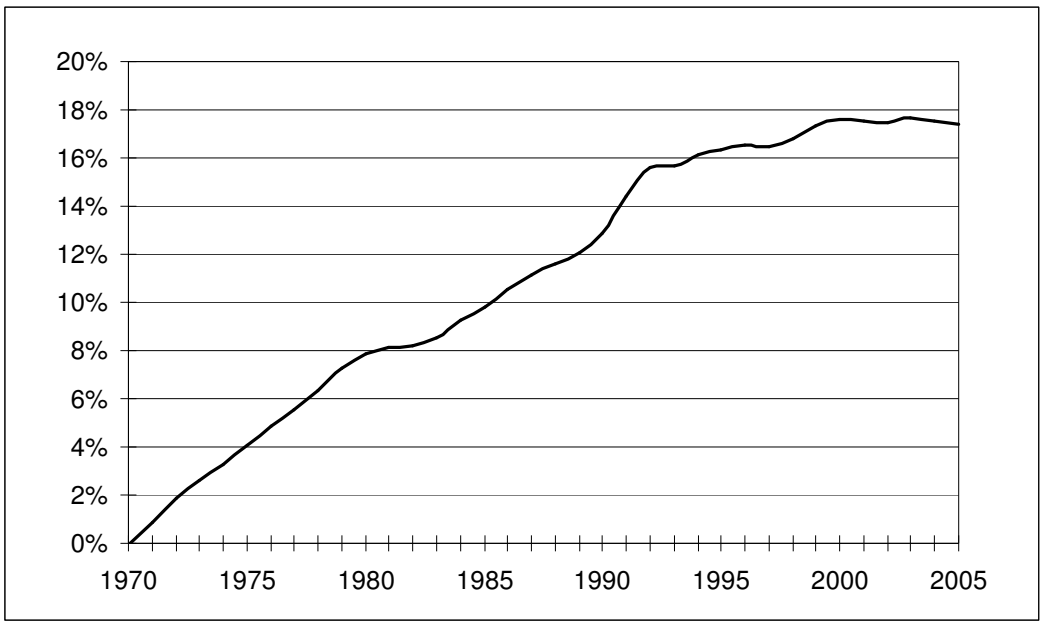

Fig. 3.3 *Shadow Economy in Germany in Percentage of GDP (1990:2005)*

Figure 3.4 illustrates the estimated size and development of DIY activities under the S-DIY model specification. Do-it-yourself activities as a percentage of official GDP increased from 4.05% in 1970 to 4.94% in 1995 and remained more or less stable through 2005. Like shadow economic activities, DIY activities also experienced a big push following German reunification – even though the dynamics were not as pronounced. On the whole, between 1970 and 2005, DIY activities grew more slowly than did the shadow economy.

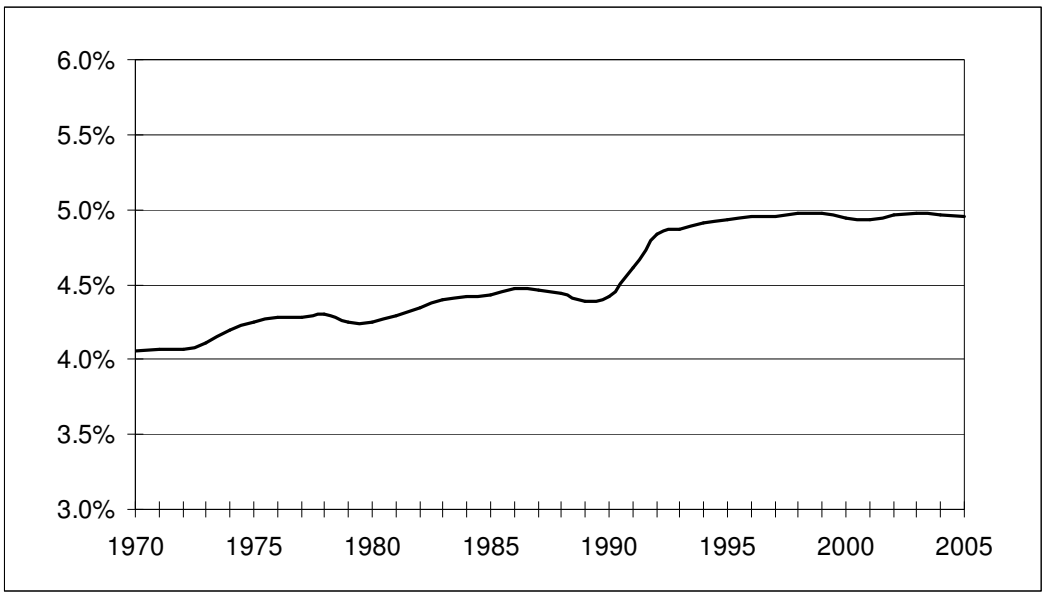

Fig. 3.4 *DIY Activities in Germany in Percentage of GDP (1970:2005)*

When calculating the size and development of shadow economic and DIY activities in Germany according to the H-DIY model, we obtain similar results. As Figure 3.5 shows, DIY activities ranged from 3.87% (1970) to 4.99% (2005) whereas the shadow economy increased from 1.63% (1970) to 16.11% (2005). Accordingly, the benchmark value for the H-index is simply derived by adding the *a priori* known values for the shadow economy and for the DIY activities taken from Karmann (1990). As a result, our benchmark for the hidden economy in 1983 is 12.9% of official GDP. All estimates of the different index series according to the S-DIY and the H-DIY model are shown in Table 5.5 in the Appendix.

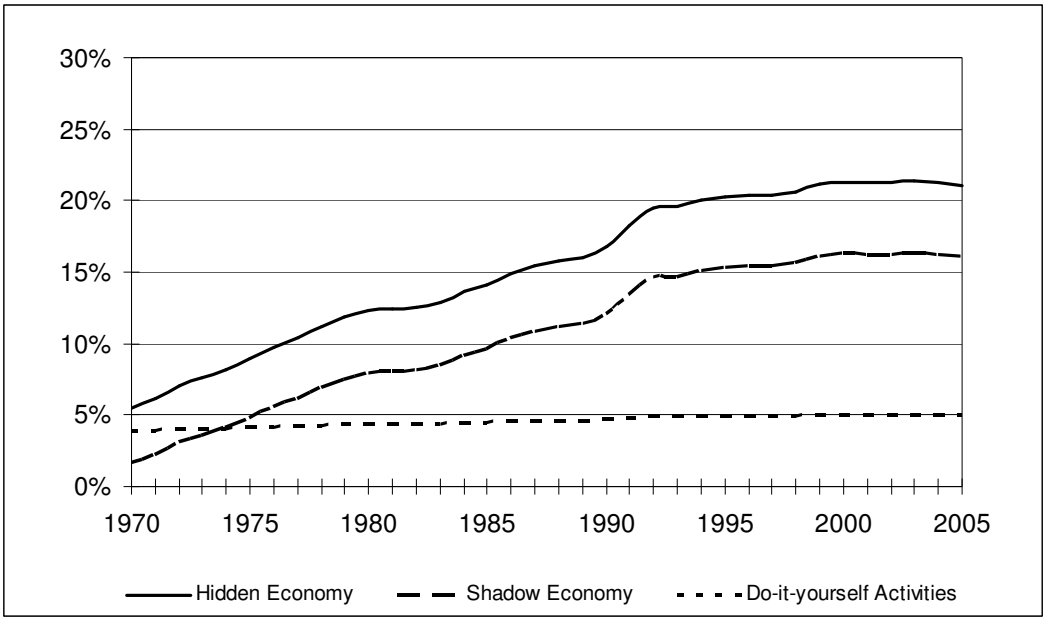

Fig. 3.5 *Time Path of the Different Indices According to the H-DIY Model in Percentage of GDP (1970:2005)*

4. Summary and Conclusions

In this paper, we have used a latent estimation approach, here, a MIMIC model, to provide the first consistent estimate of the size and development of the shadow economy and of DIY activities in Germany. In addition, we found a highly statistically significant influence of regulation as well as tax and social security contribution burdens on the shadow economy. For DIY activities, we observed a highly statistically significant positive influence of unemployment. In general, the estimated MIMIC model shows satisfactory statistical properties. According to our calculations the German shadow economy increased from 2% in 1970 to 17% in 2005. These results are very similar to those obtained by Schneider (2005) using the currency demand approach (compare table 2.1). Do-it-yourself activities amounted to 4% of official GDP in 1970, increased to 4.94% in 1995, and remained relatively constant till 2005. Taking both sectors together, we see that the hidden economy in Germany reached a remarkable size of more than 20% of official GDP in 2005.

What type of policy conclusions can we draw from these results?

(1) The simultaneous and consistent estimation of conjoint shadow economic and DIY activities yields values of 16% of official GDP for the former and 5% of official GDP for the latter for the past 4-5 years.
(2) If one wants to reduce the shadow economy and/or DIY activities, our results indicate that fewer regulations and lower tax and social security contribution burdens might be the two most efficient means of shifting more activity into the official economy. Reducing both the intensity of regulation and the amount of contributions to the social security system in Germany might also result in a lower level of unemployment. This would reduce the public's incentive to engage in DIY activities.

(3) Though our results should be regarded as first steps in measuring the size of the hidden economy, we have demonstrated that both shadow economic and DIY activities are important and should be taken into account when seeking to stimulate the official economy through policy measures.

5. Appendix

5.1. Tables

Table 5.1

Data Sources

Variable	Data source
CPI	Federal Statistical Office of Germany
Curr	Deutsche Bundesbank, own calculations
GDP	Federal Statistical Office of Germany
Grgdp	Own calculations
Hours	Federal Statistical Office of Germany
Income	Deutsche Bundesbank
Inf	Own calculations
Reg	Federal Statistical Office of Germany, own calculations
Total population	Federal Statistical Office of Germany (Thomsen Financial Datastream)
Tdiy	A.C. Nielsen Company GmbH, own calculations
Tbur	Organisation for Economic Co-operation and Development (OECD)
Unemp	Federal Statistical Office of Germany
Wages	Federal Statistical Office of Germany, own calculations

Table 5.2

Unit Root Tests for the Time Series in Levels

	PP test		**Schmidt-Phillips test**	
Variable	Test statistic	Lag length	Test statistics	Lag length l_q
Curr	-1.6614	2	-1.6453	3
			-1.6827	9
Hours	-1.3969	4	-1.3356	3
			-1.5648	9
Income	-1.7008	0	-1.7062	3
			-1.6475	9
Inf	-2.8782	1	-2.4181	3
			-1.4623	9
Reg	-0.6600	6	-1.2617	3
			-1.4921	9
Tdiy	-1.0553	4	-1.1893	3
			-1.4762	9
Tbur	-1.0229	3	-1.7221	3
			-1.7460	9
Unemp	-2.5858	2	-2.7828	3
			-1.5601	9
Wages	-4.8518	1	-0.4709	3
			-0.5398	9

The order of the autoregressive correction for the PP test was chosen using the Bartlett kernel estimator and the Newey-West (1994) data-based automatic bandwidth parameter method. All regressions for the PP test include an intercept and a time trend. The critical values for the PP test – taken from MacKinnon (1996) – are: -4.24 (1% level), -3.54 (5% level), and -3.20 (10% level). The suggestion for the choice of the lag-length in the Schmidt-Phillips test is to use $l_q = q(T/100)^{1/4}$, where $q = 4$ or $q = 12$, which results in a lag-length of 3 and 9, respectively. The critical values for this test – tabulated in Schmidt and Phillips (1992) – are: -3.55 (1% level), -3.02 (5% level), and -2.75 (10% level).

Table 5.3

Robustness Checks S-DIY MIMIC Model

	1971-2005		**1972-2005**		**1973-2005**		**1970-2004**		**1970-2003**		**1970-2002**		**Ex insignificant variables (1970-2005)**	
	S	**DIY**	**S**	**DIY**	**S**	**DIY**	**S**	**DIY**	**S**	**DIY**	**S**	**DIY**	**S**	**DIY**
Indicator variables														
Curr	1		1		1		1		1		1		1	
Grgdp	0.27***		0.27***		0.26***		0.27***		0.30***		0.25***		0.28***	
	(3.25)		(3.17)		(3.06)		(3.19)		(3.13)		(3.07)		(3.29)	
Hours	-0.02		-0.02		-0.02		-0.02		-0.02		-0.01			
	(-1.31)		(-1.16)		(-1.12)		(-1.17)		(1.04)		(-0.77)			
Tdiy		2		2		2		2		2		2		2
Causes variables														
Reg	12.12**		12.17**		12.48**		11.83**		12.08**		13.08**		11.94**	
	(2.63)		(2.59)		(2.55)		(2.55)		(2.59)		(2.63)		(2.64)	
Income	1.34***		1.34***		1.41***		1.34***		1.25***		1.45***		1.28***	
	(3.22)		(3.11)		(3.02)		(3.16)		(2.97)		(3.23)		(3.12)	
Inf	-0.25	-0.62**	-0.24	-0.59**	-0.35	-0.58**	-0.27	-0.57**	-0.11	-0.55**	-0.49	-0.54**		-0.53**
	(-0.39)	(-2.33)	(-0.35)	(-2.21)	(-0.49)	(-2.09)	(-0.42)	(-2.15)	(-0.18)	(-2.03)	(-0.72)	(-2.08)		(-2.28)
Dummy	0.09**	0.05***	0.09**	0.05***	0.09**	0.04***	0.09**	0.05***	0.09**	0.05***	0.10**	0.05***	0.09**	0.04***
	(2.38)	(4.01)	(2.33)	(3.86)	(2.34)	(3.63)	(2.41)	(3.92)	(2.29)	(3.77)	(2.45)	(4.08)	(2.37)	(4.25)
Tbur	0.11**	-0.01	0.11**	-0.01	0.11**	-0.01	0.11**	-0.00	0.12**	-0.01	0.12**	0.00	0.09**	
	(2.34)	(-0.35)	(2.28)	(-0.35)	(2.22)	(-0.35)	(2.29)	(-0.27)	(2.43)	(-0.44)	(2.18)	(0.08)	(2.12)	
Unemp		0.03**		0.03**		0.03*		0.03**		0.03**		0.03**		0.04***
		(2.11)		(2.04)		(1.86)		(2.19)		(2.15)		(2.44)		(2.75)
Wages		0.15		0.16		0.17		0.11		0.11		0.09		
		(0.78)		(0.78)		(0.68)		(0.58)		(0.56)		(0.46)		

T-statistics appear in parenthesis. * = significance at 10% level, ** = significance at 5 % level, *** = significance at 1% level.

Table 5.4

Robustness Checks H-DIY MIMIC Model

	1971-2005		**1972-2005**		**1973-2005**		**1970-2004**		**1970-2003**		**1970-2002**		**Ex insignificant variables (1970-2005)**	
	H	**DIY**	**H**	**DIY**	**H**	**DIY**	**H**	**DIY**	**H**	**DIY**	**H**	**DIY**	**H**	**DIY**
Indicator variables														
Curr	1		1		1		1		1		1		1	
Grgdp	0.23***		0.21***		0.20***		0.23***		0.25***		0.22***		0.29**	
	(3.17)		(3.00)		(2.84)		(3.11)		(3.15)		(2.95)		(2.43)	
Hours	-0.01		-0.01		-0.01		-0.01		-0.01		-0.01			
	(-1.10)		(-0.95)		(-0.91)		(-0.96)		(-0.83)		(-0.59)			
Tdiy		2		2		2		2		2		2		2
Causes variables														
Reg	11.59**		11.46**		11.61**		11.17**		11.90**		11.71**		10.59**	
	(2.55)		(2.45)		(2.40)		(2.44)		(2.54)		(2.43)		(2.43)	
Income	1.40***		1.43***		1.48***		1.39***		1.38***		1.43***		1.18***	
	(3.42)		(3.36)		(3.23)		(3.33)		(3.23)		(3.29)		(2.96)	
Inf	-0.86		-1.18		-1.70**		-0.85		-0.68		-1.00			
	(-1.31)		(-1.63)		(-2.52)		(-1.29)		(-1.03)		(-1.44)			
Dummy	0.12***		0.13***		0.13***		0.13***		0.12***		0.14***		0.11***	
	(3.13)		(3.22)		(3.20)		(3.15)		(2.96)		(3.21)		(2.77)	
Tbur	0.09**		0.09*		0.09*		0.09*		0.11**		0.10*		0.09*	
	(2.06)		(1.90)		(1.83)		(2.02)		(2.18)		(1.96)		(2.01)	
Latent variable														
H		0.13*		0.13*		0.13*		0.13*		0.11		0.14*		0.14*
		(1.96)		(2.00)		(1.98)		(1.88)		(1.58)		(2.00)		(1.82)

T-statistics appear in parenthesis. * = significance at 10% level, ** = significance at 5 % level, *** = significance at 1% level

Table 5.5

Size of the Hidden Economy, the Shadow Economy and of DIY Activities (in Percentage of GDP) (1970:2005)

	Hidden economy		Shadow economy		Do-it-yourself activities	
Year	H-DIY model	S-DIY model	H-DIY model	S-DIY model	H-DIY model	S-DIY model
1970	4.02	5.50	-0.04	1.63	3.87	4.05
1971	4.92	6.16	0.86	2.24	3.92	4.07
1972	5.95	7.08	1.88	3.10	3.98	4.07
1973	6.71	7.57	2.60	3.55	4.02	4.11
1974	7.48	8.17	3.28	4.11	4.06	4.20
1975	8.34	8.97	4.09	4.85	4.12	4.25
1976	9.16	9.76	4.88	5.59	4.17	4.28
1977	9.84	10.37	5.56	6.15	4.22	4.28
1978	10.65	11.17	6.35	6.90	4.28	4.30
1979	11.52	11.88	7.27	7.55	4.33	4.25
1980	12.11	12.28	7.85	7.93	4.36	4.25
1981	12.43	12.45	8.14	8.09	4.37	4.29
1982	12.58	12.54	8.23	8.17	4.37	4.35
1983	12.90	12.90	8.50	8.50	4.40	4.40
1984	13.66	13.60	9.24	9.15	4.45	4.42
1985	14.23	14.10	9.80	9.61	4.49	4.43
1986	15.01	14.92	10.54	10.38	4.55	4.47
1987	15.61	15.44	11.14	10.86	4.58	4.47
1988	16.03	15.77	11.59	11.16	4.61	4.44
1989	16.47	16.03	12.08	11.41	4.62	4.39
1990	17.31	16.78	12.90	12.10	4.68	4.42
1991	19.03	18.24	14.42	13.45	4.78	4.61
1992	20.44	19.50	15.60	14.63	4.87	4.84
1993	20.56	19.56	15.68	14.68	4.88	4.87
1994	21.05	20.05	16.15	15.13	4.91	4.91
1995	21.26	20.25	16.32	15.32	4.93	4.94
1996	21.46	20.40	16.51	15.46	4.94	4.96
1997	21.44	20.33	16.48	15.40	4.93	4.96
1998	21.76	20.65	16.79	15.69	4.96	4.97
1999	22.29	21.12	17.31	16.13	4.99	4.97
2000	22.56	21.30	17.61	16.29	5.00	4.94
2001	22.48	21.23	17.54	16.23	5.00	4.94
2002	22.46	21.23	17.50	16.23	5.00	4.96
2003	22.63	21.39	17.66	16.38	5.01	4.97
2004	22.48	21.23	17.51	16.23	5.00	4.96
2005	22.35	21.10	17.40	16.11	4.99	4.96

5.2. Domestic Demand for Currency in Circulation in Germany

The Goldfeld (1973) equation provides the analytical background for our approach. In equilibrium, real money demand is assumed to depend on real income and the level of short term interest rates. In countries with weak national currencies, however, two or more sound currencies are often used simultaneously as means of payment and as store of values. Like Seitz (1995), we take this fact into account and include the EUR/USD exchange rate to reflect both the relative strength of the Euro over the US-Dollar as well as the observation that both currencies are close substitutes in such countries. Dummy variables for the first and second quarter of 1991 are used to control for the impact of German reunification.

To predict the level of domestic currency in circulation, we apply a vector error correction model using the methodology developed in Johansen (1991, 1995) to detect cointegrating relations. Our data are on a quarterly basis from Q1 1970 to Q4 2005. The variable GDP, measuring real income, is expressed in logarithm. The data for currency in circulation and for the short term interest rate are taken from the Deutsche Bundesbank. Data for the German quarterly GDP and for the EUR/USD exchange rate are from Thomson Financial Datastream. All variables are found to be I(1). Applying the Johansen cointegration test for the long run part of the vector error correction model, we find one cointegration equation at the 5% significance level for the four variables under consideration. In order to achieve stationarity for the short run, we then difference all variables once. The results of the unit root tests as well as of the Johansen cointegration test are presented in Table 5.6.

Table 5.6

Currency in Circulation

	PP unit root test	
Variable	Variable in levels	First difference
Currency in circulation	-1.9506 (0.6227)	-11.8498 (0.0000)
GDP	-1.4219 (-0.8506)	-11.9054 (0.0000)
Short term interest rate	-3.0510 (-0.1223)	-9.2914 (0.0000)
EUR/USD exchange rate	-1.3888** (-0.8603)	-9.7402 (0.0000)
Cointegration test		
Trace test	54.3611 (0.0108)	
Maximum eigenvalue	30.0971 (0.0233)	

The order of the autoregressive correction for the PP unit root test was chosen using the Bartlett kernel estimator and the Newey-West (1994) data-based automatic bandwidth parameter method. All regressions for the PP test in levels include an intercept and a time trend. The critical values – taken from MacKinnon (1996) – are: -4.02 (1% level), -3.44 (5% level), and -3.15 (10% level). For the first difference of the variables, the test includes an intercept only. Here, the critical values (also from MacKinnon (1996)) are: -3.48 (1% level), -2.88 (5% level), and -2.58 (10% level). The 5% critical value for the trace and maximum eigenvalue tests are 47.86 and 27.58, respectively, and are taken from MacKinnon *et al*. (1999).

The vector error correction model allows us to determine the level of domestic currency in circulation in accordance with the economic conditions in Germany from 1970 to 2005. Hence, we adjust the total amount of currency in circulation provided by the Deutsche Bundesbank by the fraction circulating abroad. Figure 5.6 shows the outcome.

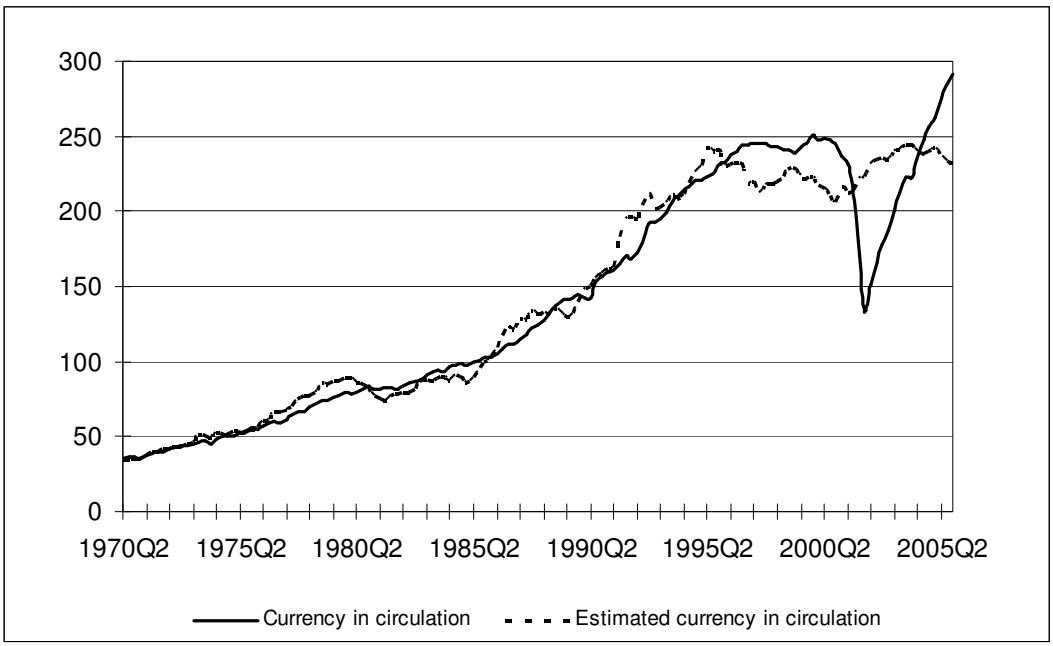

Fig. 5.6 *Currency in Circulation in Billions of Euros (1970:2005)*

5.3. Extrapolation of Turnover in German DIY stores

Because the A.C. Nielsen Company GmbH conducted the first annual survey on turnover in DIY stores in Germany in 1978, completing the time series for the entire period 1970-2005 requires estimation of the turnover for the missing years. To do this, we first calculate the annual growth rates (Grtdiy) as the first difference of the natural logarithm of the initial time series. We then simply regress the obtained growth rates on a constant term and on time. Table 5.7 shows the results of this estimation.

Table 5.7

Regression of Grtdiy on a constant and on time

Variable	Grtdiy
Parameter estimates	
Constant	0.2119***
	(0.0000)
Time	-0.0082**
	(0.0000)
Test statistics	
Standard error of regression	0.03955
Adjusted R^2	0.7131
DW-statistic	2.57
Unit root tests	
PP test	-6.3697
KPSS test	0.0827

The order of the autoregressive correction for both unit root tests was chosen using the Bartlett kernel estimator and the Newey-West (1994) data-based automatic bandwidth parameter method. All regressions for the PP test include an intercept and a time trend. The critical values for the PP test – taken from MacKinnon (1996) – are: -4.37 (1% level), -3.60 (5% level), and -3.24 (10% level). The LM statistics critical values of the KPSS test – taken from Kwiatkowski *et al.* (1992) – are: 0.2160 (1% level), 0.1460 (5% level), and 0.1190 (10% level).

Finally, we use the estimates to predict and integrate annual growth rates of turnover for the years 1971 to 1978. A graphical representation of turnover in DIY stores from 1970 to 2005 is provided in Figure 5.7.

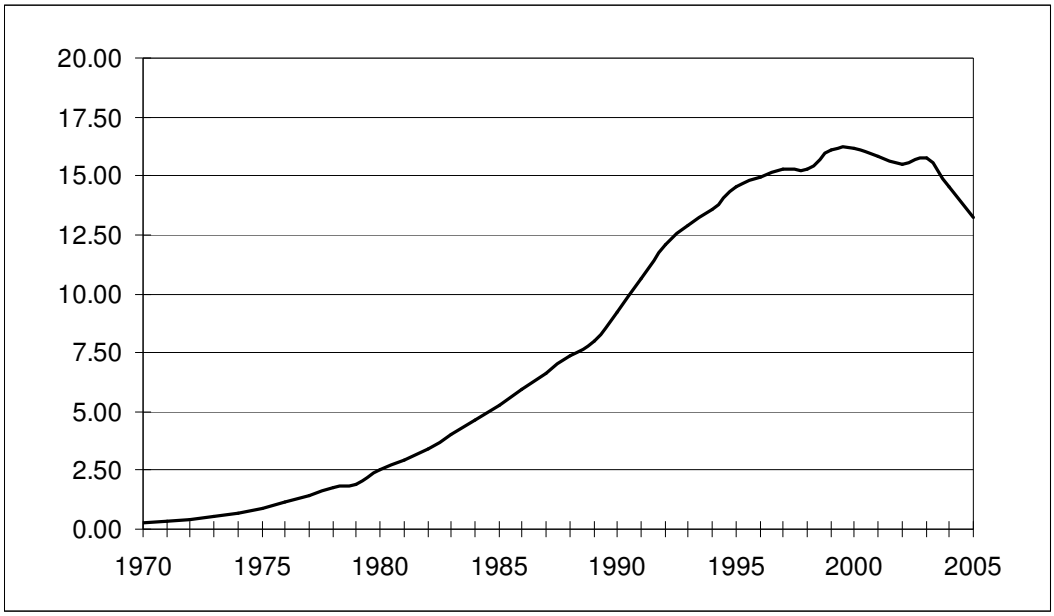

Fig. 5.7 *Turnover in DIY stores in Billions of Euros (1970:2005)*

6. Literature

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