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Economic Growth and Business Cycles in Liechtenstein

Econometric Investigations Considering the Past, Present, and Future

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In loving memory of my dear "Ahna" (grandmother)

Rosa "Rosele" Brunhart-Frick

and of many more who live on in my heart

Prologue

So far, time serial and econometric methods could only be applied to a limited extent in the study of Liechtenstein's economy. One main reason was the lack of appropriate economic data series, be it the shortness of annual historic time series, the existence of data gaps or also the lack of adequate quarterly indicators for the sub-annual analysis. This book is a slightly revised version of my PhD-thesis[1] at the University of Vienna (submitted in 2012), which represents very applied economics with an emphasis on econometrics. It is a contribution to the economic data base of Liechtenstein in order to resolve existent statistical matters in the field of economic and econometric research (especially economic history and business cycle research). It also is an early attempt to apply these new historic data series combined with the introduction of new tools and first insights economically relevant for Liechtenstein. The main contributions of this PhD-thesis consist of the following:

> [1] Liechtenstein's economic data base is being extended. The generated series consist for instance of the national income 1954-1992 (regressive inter- and retropolation with indicators) and 1993-1997 (approximative computation in line national accounting scheme), the sectoral and total employment of some missing years in the 70s, 80s and 90s and the gross domestic product 1972-1997 (approximative computation/estimation following the generation of income account of national accounts). These series can be linked with the officially released results from the national accounts, which were introduced for the year 1998 and published until 2009 so far.[2] On this base, first conclusions about the business cycle pattern in Liechtenstein and its long-term growth can be drawn. Also, a benchmark model is being presented, which serves as a supporting supplement to the annual GDP-forecast for Liechtenstein's economy that is carried out by the Konjunkturforschungsstelle Liechtenstein (KOFL).

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[1] Feel free to contact me via economics@brunhart.com or just visit my homepage http://andreas.brunhart.com.

[2] These generated time series are now included into Liechtenstein's official statistical yearbook.

[2] A composite (coincident) business cycle indicator is developed, called "KOFL KonSens". In this vein, a valuable complement to the ordinary business cycle definition, which concentrates on the cyclical deviation from the trend of certain separate economic aggregates, is provided. By the detection and filtering of a common business cycle signal of multiple indicators, the KOFL KonSens generates a broader foundation for business cycle analysis and therefore also a new base for prediction. Also quarterly figures for Liechtenstein's GDP are estimated for the first time.

[3] The impact of the "Zumwinkel-Affair" (a whistle-blower sold data of hundreds of tax evaders to international tax authorities) separated from the financial crisis, on the daily stock prices of banks from Liechtenstein is investigated. An "unconventional", augmented GARCH-model (labelled as "augmented amalGARCH") is introduced and analyses the dynamical pattern and other influences on risk and average performance.

First of all, I want to thank *Prof. Carsten-Henning Schlag* (University of Liechtenstein and Konjunkturforschungsstelle Liechtenstein) and his wife *Dr.-habil. Kersten Kellermann* (Konjunkturforschungsstelle Liechtenstein) for their support and advice regarding my thesis and for many discussions about economics and other things. I would also like to express my gratitude to *Prof. Robert Kunst* (University of Vienna and Institute of Advanced Studies). His PhD-courses at the University of Vienna were very useful and interesting and his supervision of my dissertation extremely supportive and prompt. Thanks go also to *Prof. Michael Hauser* (Vienna University of Economics and Business) for the willingness to be the external examiner of my dissertation. Also, I want to mention *Prof. Winand Emons*, *Prof. Aymo Brunetti* and *Prof. Klaus Neusser* from the University of Bern. Their Economics courses during my first year of the introductory part of my diploma studies at the University of Bern were extremely valuable and convinced me to prefer Economics as my main-subject over the other selectable subjects, a decision that I have never regretted. I am also very

grateful to all the people employed at different national authorities who had to deal with my concerns. They were all very patient, helpful and reliable, especially *Dr. Wilfried Oehry* and *Mario Schädler* from the national office of statistics (Amt für Statistik), *Thomas Lorenz* from the governmental financial unit (Stabstelle Finanzen), and the former head of the national tax administration (Liechtensteinische Steuerverwaltung) *lic.oec. Marco Felder*, *MBL HSG*. I may also not forget all the kind employees at the national library (Liechtensteinische Landesbibliothek) who had to cope with my endless requests to go and get sources from the archive. Also, a huge gratitude goes to all the companies who provided information in the extensive data compilation process of the first part of this thesis. Without this support the newly developed procedure for the backward estimation of GDP would not have been applicable. Yet, since this data was mainly confidential, I cannot mention all the individual companies here. I also want to thank *Dr. Ronald Kranz* for providing me access to his doctoral thesis.

Above all, I have to emphasize my deep thankfulness to my parents Bernadette and Hans. You were always there for me, with loyalty and patience (…hell yeah, I know how much patience I have required every now and then!). Both of you have been good examples, inspirations and tough challenges at the same time and you have guided me in so many ways on my path to become the person I am now. Needless to say that I love you both! I also want to thank the rest of my family, my sister Ines and my brother Patrick and his wife Tamara for being great "big brothers and sisters". I especially want to thank my nieces Larissa and Helena for touching my heart uncountable times and always reminding me that there are far more important things in life than numbers, graphs and regressions. For some reason (which I am constantly trying to figure out), I am blessed with so many good friends; be it from school (especially the "vicious" last row), from my soccer club FC Balzers, from university and social life in Bern and Vienna and from many other places. It is so hard to sample and mention just a few, that is why I leave it. Thanks for your support (but also for all the fun times contrasting my work during the previous

years), you all know who you are![3] The hospitality of Vienna was overwhelming during my PhD-studies (especially the Papalapub with Simon and Mario, the Molly Darcy's Pub and Die Serviette, where my cousin Ruben was always a good host and fabulous chef).

This dissertation and the PhD-courses were a great challenge and a very interesting experience. I am happy that I faced it, but on the other hand I am a bit sad that this adventure is over now (as "Lemmy" Kilmister put it: "The chase is better than the catch"). But there will be new challenges (or chases) in my life, especially my work at the Liechtenstein-Institut and the Konjunkturforschungsstelle Liechtenstein.

Last but not least I am grateful for all the luck and opportunities I have had so far and I want to express my gratitude for my life being such a breathtaking rollercoaster-ride all the time. I usually do not understand the big advantage of cheesy quotations in the beginning of books and anyway I have been quite successful in trying to ignore any kind of well-meant advice so far. But one suggestion turned out to be very appealing to me over the years and that is why I cannot resist quoting this superbly sarcastic but true (and in a way very positive) advice from a song by William Shatner:

„Live life like you're gonna die,…

…because you're gonna!"

---

[3] Ok, I still need to mention just a few due to their specific relevance for this dissertation and thank them especially for their constant intellectual and spiritual support that contributed to the completion of this thesis. Among these people are (in alphabetical order): *Benedikt Biedermann, Berno Büchel, Andrea Büchel-Biedermann, Martin Gassner*, *Emanuel Gasteiger, Dominik Kranz, Thomas Lageder, Torsten Lisson, Seraina Peter, Walter Sinn, Dominique Sinn-Sparber, Georg Sparber, Yvonne Sparber-Kranz, Petra Sprenger,* and *Bettina Wenaweser.*
Maybe I should also give a high five to the inventers of energy drinks and McChrystal's at this occasion: They were efficient little helpers in the sometimes exhausting process of drawing up and writing this manuscript. Exactly the opposite claim holds for the construction enterprise PORR and our landlord company Kloster Neustift (which by the way achieved the perfect synthesis of religion and complete profit maximization) along with their almost two-year lasting construction site in and around our apartment building in Vienna: A never-ending source of noise, dust, trouble, but also amusement and sarcasm (enough for a new manuscript with even more pages than this thesis).

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1.

Backward Calculation, Revision and Provision of Historic Economic Data Series to Enhance Econometric Research and Forecasting in Liechtenstein♠

♠ Chapter 1 of this dissertation was released in BRUNHART [2012b] as *KOFL Working Paper* No. 14 (series issued by KOFL Liechtenstein Economic Institute). A summarizing (German) version was published as *KOFL Economic Focus* No.4 and No. 5 (BRUNHART [2012c and 2012d]).
I would like to thank *Prof. Robert Kunst* (University of Vienna), *Dr. Ines Brunhart* and *lic.iur. Patrick Brunhart* for cross-reading chapter 1 of this PhD-thesis and helpful comments.

1.1. Introduction

The first chapter of this dissertation thesis deals with the fact that there exist some special issues in Liechtenstein in the field of economics or economic history, but especially when it comes to business cycle and growth research or econometric forecasting. These issues concern the scarce data base of economic time series: The short time coverage of national aggregates, such as GDP or (gross) national income, complicate business cycle analysis and prediction. Officially published national accounts for these aggregates only exist for the years 1998-2010 (see OFFICE OF STATISTICS [2011 and 2012b]). Detailed official annual employment figures are only on hand from 1980 on. In most applications so far, time serial and econometric methods could only be applied to a limited extent to examine economic matters due to the shortness of the time series. Hence, the main aim and contribution of this first chapter is the prolonging of important economic time series for Liechtenstein, the filling of data gaps, the adjustment for outliers and a first application of the prolonged series, in the case here for forecasting purposes.[4]

There have been earlier estimations for gross domestic product and national income of Liechtenstein, at least for some years: KNESCHAUREK AND GRAF [1990] and KNESCHAUREK AND PALLICH [1982] have approximated real and nominal GDP for the years 1960, 1970, 1975, 1980-1988 and 1991. Also, BECK [1961 and 1963], SCHNETZLER [1966] and KRANZ [1973] have published estimates of national income for the years 1959-1963 and 1966-1970. However, for any deep econometric analysis of economic matters, the time series need to be consistent and without data gaps. That is why there is an additional need, beyond the analytical interest in the time series themselves, for a new series with estimated GDP figures, which are computed in this contribution for the years 1997 back to 1972. Along with this project, coherent total and sectoral employment figures for the 70s have been

[4] A rise of the frequency of Liechtenstein's GDP from annual to quarterly figures will take place in the second chapter (2.4.).

supplied. Also, a historical adherent time series of the national income is being generated.

There are three reasons why not only Liechtenstein's GDP is calculated for earlier years than the official figures currently available but also the time series of national income is backwardly extended: First, national income is required in the chosen computation process of the backward calculations of Liechtenstein's GDP. Secondly, national income has a long tradition in Liechtenstein (with existing estimates for the late 50s, the 60s and the early 90s) and is a main pillar of the official national accounts. Thirdly, a generation of linked time series back covering years until 1954 is possible, while the new computations of GDP only reach back until 1972. Even though, these days the national income is a bit outdated as an important indicator in economic analyses and international comparisons it is not obsolete as it is strongly related and highly correlated to the commonly used gross national income (the exact differences between the two related aggregates are explained in chapter 1.2. and the beginning of 1.3.).

Now, as a long GDP-series is generated in chapter 1.4. and therefore exists for the years 1972-2011, an additional kind of prediction-model can be introduced in the form of a non-structural approach that complements the existing and rather structural approach by the Liechtenstein Economic Institute (Konjunktur-forschungsstelle Liechtenstein, KOFL). This model can apply the full available GDP-sample and not just 1998-2011 and represents a "cheap" benchmark-model for complementation and validation purposes.

The next chapter (1.2.) will deal with the structure of Liechtenstein's official national accounts (Volkswirtschaftliche Gesamtrechnung, VGR FL). In chapter 1.3., the national income figures from 1954 until 1997 are being generated and methodically explained. Further on, the GDP figures 1972-1997 and their computation approach are presented in chapter 1.4., which also contains the introduction of a benchmark

prediction model supplementing the already existing annual forecasts of Liechtenstein's GDP carried out by KOFL. Chapter 1.5. will conclude this contribution.

1.2. National Accounting for Liechtenstein

Before dealing with the applied approach for generating a coherent and accurate GDP-series (and national income), it is worth paying some attention to the system of national accounts[5], especially to the case of Liechtenstein.

OEHRY [2000] has elaborated and introduced the national accounts for Liechtenstein.[6] Along with the official national accounts, Liechtenstein's GDP is being calculated from the production and the income sides and is supplemented by two further accounts, which are the gross national income account ("Nationaleinkommenskonto") and the national income account ("Volkseinkommenskonto"). These two latter accounts are adopted from the old System of National Accounts (SNA58, OECD [1958]) and link the income side with the production side. The principles of the detailed transactions of all the accounts rely on ESA95, the European System of Accounts of EUROSTAT [1995] which essentially was the European version of the SNA93 (System of National Accounts 1993 by UNITED NATIONS [1993]). The results are therefore directly comparable with national accounts from other countries. The lack of important data, such as

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[5] Early pioneers in the field of national accounts were William Petty (1623-1687) and Gregory King (1648-1712). They computed aggregated population, labour input, capital stock and consolidated wealth/income accounts for England and Wales. Colin Clark produced the first integrated accounts for the UK (income, expenditure, production at constant/current prices), and linked his estimates 1913 with those of King and acted together with John Maynard Keynes, who was somehow the "father" of the British national accounts, promoting the importance of national accounts as a tool of economic policy (see CLARK [1940] and KEYNES [1940]). Clark was the first who estimated comparable real income levels of different countries taking differences in purchasing power of currencies into account. International standards for national accounting were set by Richard Stone (he designed the standardized system of national accounts, for which he was awarded the Nobel Prize in Economics), Simon Kuznets (who introduced national accounts in the US), and Milton Gilbert (being responsible for US accounts during World War II and the Marshall Plan accounts). Angus Maddison has contributed pioneering comparable computations and historic estimates of national economic aggregates for countries worldwide and over a long period back in time. For more information about the history of national accounts and important contributions see MADDISON [2007], TILY [2009] and OEHRY [2000, p.32-40].

[6] For more details on Liechtenstein's national accounts see also KELLERMANN AND SCHLAG [2005].

national balance of payment (especially the missing capital account) makes the usual direct way from gross domestic product (GDP) to gross national income (GNI) impossible. But the two already mentioned accounts gross national income account and national income account ensure that the calculation of the GDP also occurs from the income side. This accompanies the calculation of GDP from the production side and makes reconciliation of the sub-aggregates and sub-accounts possible. The "Volkseinkommenkonto" ascertains the "Volkseinkommen", further on denoted as national income (NI), which is then adjusted via the "Nationaleinkommenskonto" to obtain the "Bruttonationaleinkommen", further on denoted as gross national income (GNI).

Production Account (Produktionskonto):
Output (Produktionswert)
- Intermediate Consumption (Vorleistungen)
+ Taxes on Products (Gütersteuern)
- Subsidies on Products (Gütersubventionen)
= Gross Domestic Product/Gross Value Added (Bruttoinlandsprodukt)
- Consumption of Fixed Capital (Abschreibungen)
= Net Value Added (Nettoinlandsprodukt)

Generation of Income Account (Einkommensentstehungskonto):
Gross Domestic Product (Bruttoinlandsprodukt)
- Compensation of Employees (Arbeitnehmerentgelt)
- Taxes on Production and Imports (Produktions- und Importabgaben)
+ Subsidies (Subventionen)
= Gross Operating Surplus (Bruttobetriebsüberschuss)

Allocation of Income Account (Einkommensverteilungskonto):
Gross Operating Surplus (Bruttobetriebsüberschuss)
+ Compensation of Employees (Arbeitnehmerentgelt)*
+ Taxes on Production and Imports (Produktions- und Importabgaben)*
- Subsidies (Subventionen)*
+ Property Income (Vermögenseinkommen)*
= Gross National Income (Bruttonationaleinkommen)*

Gross National Income Account (Nationaleinkommenskonto):
Gross National Income (Bruttonationaleinkommen)*
- Taxes on Production and Imports (Produktions- und Importabgaben)*
+ Subsidies (Subventionen)*
- Consumption of Fixed Capital (Abschreibungen)*
= National Income (Volkseinkommen)*

National Income Account (Volkseinkommenskonto):
National Income (Volkseinkommen)*
- Compensation of Employees (Arbeitnehmerentgelt)*
- Entrepreneurial Income of Self-Employees (Selbständigeneinkommen)*
- Property Income of Private Households (Vermögenseinkommen der privaten Haushalte)*
- Undistributed Income of Corporate Enterprises (Unverteilte Einkommen der Kapitalgesellschaften)*
- Direct Taxes of Corporated Enterprises (Direkte Steuern der Kapitalgesellschaften)*
- Property and Entrepreneurial Income of Public Sector (Vermögenseinkommen des Staates)*
= 0

TABLE 1: System of Liechtenstein's official national accounts

TABLE 1 summarizes the systematic of Liechtenstein's official national accounts, which has been compiled and published by Liechtenstein's national Office of Statistics since 1998 on an annual base. The first two accounts are compiled after the domestic principle (domestic production and income), while the remaining three accounts are denoted by an asterisk to highlight that they are accounted using the residents concept (income of residents of Liechtenstein that was generated in Liechtenstein and abroad).

1.3. Coherent Historic Time Series of National Income

There are reasons why not only Liechtenstein's GDP is calculated for earlier years than the official figures currently available but why also the time series of national income is backwardly extended. These reasons have been noted in the introduction. The three most important aggregates for Liechtenstein, namely gross domestic product, gross national income and national income, are defined and compared in the following.

In short terms, the distinction between GDP and GNI can be made in such a way that gross national income focusses on the income (domestic and from abroad) of residents while the gross domestic product captures the domestic production of residents and non-residents. Especially for small countries and very open economies the distinction between gross domestic product and gross national income may be very important, since there are a lot of workers commuting across the borders and these small countries usually exhibit high levels of foreign trade (possibly causing high foreign investments which increase the annual net capital income[7]) and a high amount of cross-border capital flows. The exact difference of the gross national income and the old national income is explained in the next section (the latter is compiled in the official accounts of Liechtenstein as well and plays an important role in the following chapters). The aggregate national income, yet having been very

[7] This reasoning can be illustrated for the case of Liechtenstein: The principality had highly positive net exports in the previous decades. The fact that the exports were continuously higher than the imports led to high amounts of positive net foreign investments leading to positive net capital income in each year (this is also the case for Switzerland). The identity that net foreign investment must equal net exports is a fundamental principle in economics (see for example MANKIW [2004, p.375]). However, the huge amount of daily inward commuters in Liechtenstein induces negative net (cross-border) labour income which compensate for the positive net capital income (official figures for 2010: Of the domestic employment of 34'334 people in Liechtenstein, 17'570 were inward commuting non-residents, while only 1'516 residents commuted to abroad). Until 2000, GNI and GDP in Liechtenstein were roughly of the same level, while afterwards the GNI rose slower than the GDP due to the fast growing amount of inward-commuters. This compensation channel does not appear in Switzerland, since the commuters play only an important role in very small countries, of course. Thus, the GNI of Switzerland is traditionally higher than the GDP.

important in earlier national account schemes and often mentioned in older economic literature, has been replaced by the national aggregate gross national income, which is essentially the national income plus taxes on production and imports, minus subsidies and plus consumption of fixed capital. Both aggregates are strongly related. Inspecting the official national accounts of Liechtenstein (1998-2009), one can conclude that national income and gross national income are highly correlated: The correlation coefficient of their level is 0.98 and of their growth rates 0.99.

In the official national accounts by the Liechtenstein Office of Statistics, the GDP is calculated from production and income sides (according to ESA95), supplemented by the two accounts "Nationaleinkommenskonto" and "Volkseinkommenskonto", which are both according to the old scheme after OECD [1958]. These two additional accounts link the income side with the production side, since the direct way from GNI to GDP is not possible due to the lack of important base data. There exists no detailed balance of payments for Liechtenstein. The Swiss National Bank does not publish detailed results on the balance of payments for Liechtenstein, which can be seen as regional part of the monetary and customs union of Switzerland and Liechtenstein. However, especially the capital account would be of specific interest in this context to determine the cross-border returns on capital and transnational transfers of commuters' labour income.

The full list of the five accounts was illustrated in the previous chapter (1.2.). Important here is the so called national income account, that derives the national income. In order to clarify the exact definition of the term "national income" which has been used here, the derivation of the different classifications of the national income is listed below. Especially the distinction to the frequently used gross national income is of strong relevance.

	Compensation of Employees
plus	Entrepreneurial Income of Self-Employees
plus	Property Income of Private Households
plus	Undistributed Income of Corporate Enterprises
plus	Direct Taxes of Corporate Enterprises
plus	Property and Entrepreneurial Income of Public Sector
minus	Interest on Debt of Public Sector
plus	Property and Entrepreneurial Income of Social Insurances
=	National Income (NI)
plus	Taxes on Production and Imports
minus	Subsidies
=	Net National Income (NNI)
plus	Consumption of Fixed Capital
=	Gross National Income (GNI)

TABLE 2: National income account and the difference between NI and GNI

After the rough valuation of Liechtenstein's national income for the year 1942 by the Statistical Office of Switzerland, several estimates of national income were made by different authors or institutions applying differing methods, even though they all mainly relied on the system of the table listed before. So, figures for Liechtenstein's national income have been calculated for different years and can be obtained from different sources. Even though the detailed routines for the calculation of the sub-aggregates and the used data series differ between the different authors, the procedures of the estimated figures are fairly comparable throughout the years. SCHNETZLER [1966] introduced the national income account in line with OECD [1958] and therefore set the basement procedure for the following estimates by KRANZ [1973] or the unpublished figures by the governmental financial unit (Stabstelle Finanzen). The two latter authors maintained the approach proposed by SCHNETZLER [1966], only gradually changing the calculation method of the sub-aggregates, using different data-sources, or introduced appropriate modifications. Also the official national accounting involves this account to calculate national income (and in a later step the gross national income), but in a more sophisticated way and also taking advantage of a larger data base. This data base consists also of publicly accessible data sources or figures that have been compiled exclusively for the objective of national accounting. BECK [1961 and 1963] calculated national income figures for the years 1959, 1961 and 1962: Even though these calculations

followed the structure of OECD [1958] as well, the level of the calculated figures is not directly comparable. Nonetheless, these estimates serve as a good additional reference for the interpolation later on.[8]

	National Income I	National Income II	Calculated and published by
	Nominal figures, in Mio. CHF		
1942	19.3		Statistical Office Switzerland (1945)
1959		89.0	BECK [1961]
1960	84.7	89.1	SCHNETZLER [1966]
1961		117.8	BECK [1963]
1962		130.3	
1963	122.9	133.1	SCHNETZLER [1966]
1966	167.0	184.1	KRANZ [1973]
1967	184.5	205.4	
1968	219.9	239.7	
1969	257.2	279.2	
1970	308.2	333.1	
1993	Not published		Governmental Financial Unit
1994	Not published		
1995	Not published		
1996	Not published		
1997	Not published		
1998	2'877.5		Office of Economic Affairs
1999	3'138.7		
2000	3'307.5		
2001	2'989.1		
2002	2'880.9		
2003	2'746.7		
2004	2'761.3		
2005	3'094.9		
2006	3'571.5		
2007	4'043.4		Office of Statistics
2008	3'901.4		
2009	3'221.6		

TABLE 3: Different estimates of Liechtenstein's national income

TABLE 3 shows all the years for which national income figures are available (up-to-date), differentiating after the two concepts national income I and II (the difference between both concepts is explained in OEHRY [2000, p.67] and SCHNETZLER [1966, p.12]).

[8] For a detailed explanation of the all the mentioned methods for the calculation of the national income, see BECK [1961 and 1963], SCHNETZLER [1966], KRANZ [1973] and OEHRY [2000, p.64-70].

The national income figures, which exhibit a certain comparability, are plotted in FIGURE 1. These values are the starting point for the further calculation of additional national income figures, finally leading to the chained time series from 1954 to 2009. Again, the figures by the governmental financial unit (1993-1997) cannot be displayed as they are unpublished and confidential.

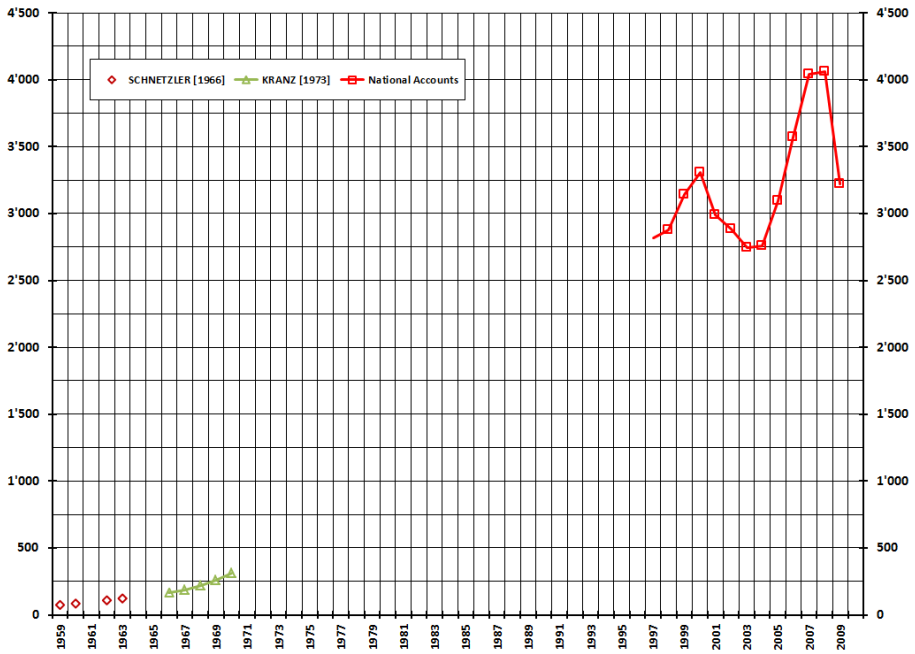

FIGURE 1: Available data points of Liechtenstein's national income

1.3.1. Backward Calculations: 1993-1997

Beginning with the year 1993, Liechtenstein authorities started to calculate the national income, mainly to get a better foundation for the division of the pool concerning several taxes and tariffs, which are collected for Switzerland and Liechtenstein collectively (for example the value added tax). As a big achievement, Gerold Matt of the financial unit of the government (Stabstelle Finanzen) set up a national income account adopting and adjusting the accounting scheme of KRANZ [1973] and SCHNETZLER [1966] and therefore the systematic of accounts after OECD [1958] (in a simplified manner). This method was also the starting point for the national income account along with the introduction of the national accounting system in Liechtenstein beginning with the year 1998 (see OEHRY [2000]). Of course, for the official national accounts the method was again adjusted and improved (and additional data sources were introduced and compiled), but the mentioned procedures all share the scheme of the national income account of OECD [1958] and are roughly comparable.

As the early national income figures were calculated for the years 1993 to 1997 but unfortunately not published, an attempt to recalculate the figures has been made in this part of the dissertation project. This could have been done since the basic needed data sources were officially collected for 1993 until 1998 and were still accessible to the author yet to be treated confidentially (by decision of the government). As already outlined, the national income is needed for the chosen approach of the calculation of the GDP figures for Liechtenstein (1972-1997). In addition to that, the calculation project of the national income 1993-1997 in this chapter had four main additional goals:

- *Open access*: The recalculation and reconciliation of the already existing but not publicly accessible national income figures for the regarded years makes

sure that a public access to these pieces of important data is guaranteed and these values may expand Liechtenstein's economic historical data series fund.

- *Consistence among years*: The original calculation method by the financial unit of the government has been divergent for different years. Especially for the more recent years, the exact computation of sub-components has been modified by the financial unit and new data sources (also in more detail) have been utilized. Thus, it was pursued in the project of this chapter to exactly unify the method for all the five years in order to gain a better comparability among the years.

- *Chaining with national accounts*: The chosen approach allows a direct conjunction with the officially published national income of the national accounts 1998-2009. For this purpose, also the year 1998 has been computed through the examined approximation method in order to get a level benchmark to the first year of the national accounts. The chosen strategy to chain both sources 1993-1998 and 1998-2009 will be explained in more detail later on.

- *Addition of observation points*: There are additional advantages of the extended data series (2009-1993) beyond the direct economic insights. The number of observation points for the national income can be increased. The currently available data points are shown in FIGURE 1. The extended observation sample constructed here diminishes statistical problems due to the originally small sample size along with the regressions. It also improves the quality of the results of the econometric interpolation mode, which generates national income estimates for the data gaps and supplies a continuous time series from 1954 to 2009. It therefore links and harmonizes national income estimates from the 60s with the current years. This will be done in the next sub-chapter.

The whole computation process for the years 1993 to 1997 is a challenging task, which cannot always be completely explicated and unveiled in full details since this would contradict the confidentiality agreement the author has signed.[9] Nevertheless, it is permitted to at least highlight almost all of the structure and the calculation methods, since it has been the base for the estimation of the national income in this paper. Also, some modifications in the method of the financial unit of the government have been introduced in order to achieve full consistence throughout the whole time span. Unfortunately, these modifications cannot be stated explicitly and major discrepancies in the calculation results will not be mentioned and explained, since this would also contradict the signed confidential agreement. Though, an explicit and detailed comparison of the newly estimated national income figures (annual totals) with the already existing results is not possible because of the same reasons. But one remark is allowed: The recalculation of the national income 1993-1997 has not only the advantage that there now exist publishable figures. Also, the pursuit of consistency has had a notable effect on the annual national income figures compared to the original (unpublished) figures. Also the chaining with the official national accounts considerably adjusted them in their levels.

Besides the consistency within the regarded time span 1993-1997, it is the main ambition to obtain national income figures that are directly comparable with figures from other time spans, mainly the ones by the official national accounts. To be precise, the calculated national income figures serve as indicators for the actual level of the national income (1993-1998) to attain a better comparability with the level of the national accounts' national income data beginning by the year 1998. The calculated national income figures are transposed into percentage changes, which are applied to the 1998-value that was published by the official national accounts. This is a methodological option that several national statistical offices use to compromise figures from varying accounting principles over time. The adjustment process will

[9] However, please contact the author of the paper (economics@brunhart.com) if there are remaining questions of general nature about the compilation method of parts that could not have been highlighted in detail due to confidential concerns. Of course, detailed confidential figures may not be revealed.

be explained later on in more detail when the sub-components of the national income account are aggregated and adjusted. The sub-accounts of the national income account shall be repeated here in TABLE 4, as the following explanations are structured according to these components:

	Compensation of Employees
plus	Entrepreneurial Income of Self-Employees
plus	Property Income of Private Households
plus	Undistributed Income of Corporate Enterprises
plus	Direct Taxes of Corporate Enterprises
plus	Property and Entrepreneurial Income of Public Sector
minus	Interest on Debt of Public Sector
plus	Property and Entrepreneurial Income of Social Insurances
=	National Income (NI)

TABLE 4: National income account

1.3.1.1. Compensation of Employees

The compensation of employees within the national income account include all incomes that have been earned by residential employees. It also includes payments of the employers for the employees' social insurance.

The sum of all incomes relevant for income taxes can be obtained from data of Liechtenstein's Tax Administration (Liechtensteinische Steuerverwaltung). As it is aimed to calculate the compensation of employees in a first step, the division of the sum of all incomes into employees' income and self-employees' income is needed. To obtain the employees' income share one needs to apply an appropriate indicator. For this reason, another important data source, namely the public pension insurance (Alters- und Hinterlassenenversicherung, AHV), is used. All employees have to contribute to AHV (currently 3.8% of the income)[10]. All employees' aggregated incomes, which are subject to these contributions, are collected and published by AHV. Also self-employees have to contribute to the public pension system. These aggregated self-employees' incomes are collected and published as well by AHV.

[10] Also the employers have to contribute to the AHV with 3.8% of the employee's salary.

These two annually published figures give a very good proxy for the share of employed income and self-employed income within the economy.

	CHF	1993	1994	1995	1996	1997	1998
	Labor Income	1'001'122'000	1'048'656'000	1'094'324'000	1'131'949'000	1'200'275'000	1'248'350'101
*	Share Employees	0.9487	0.9562	0.9555	0.9557	0.9575	0.9607
=	Income Employees	949'793'429	1'002'712'604	1'045'670'784	1'081'782'378	1'149'213'580	1'199'289'942

TABLE 5: Income of employees

In a next step, the payments of the employers for the employees' social insurance have to be estimated and added to the just calculated incomes of employees. This is done using an indicator called "social mark-up". The social mark-up sums up all the average contributions by the employer for the employee's social insurance (in percentage of employee's income): This includes pension insurance, widow(er) and orphan insurance, invalidity insurance, family benefits, unemployment insurance, obligatory health insurance and occupational accident insurance.

*Income of employees * social mark-up = compensation of employees*

The aggregated incomes of all employees are adjusted by this social mark-up, which is simply the total of percentage points of all the just mentioned contributions, which the employer in average contributes as a percentage of the employee's income (as listed in TABLE 6).

	CHF	1993	1994	1995	1996	1997	1998
	Income Employees	949'793'429	1'002'712'604	1'045'670'784	1'081'782'378	1'149'213'580	1'199'289'942
*	Social Mark-Up	1.1657	1.1670	1.1667	1.1686	1.1705	1.1717
=	Compensation of Employees	1'107'149'506	1'170'189'674	1'220'025'931	1'264'149'251	1'345'131'511	1'405'167'249

TABLE 6: Income of employees and social mark-up

1.3.1.2. Entrepreneurial Income of Self-Employees

Besides the income of employees, self-employees are also of relevance. Again, the sum of all incomes collected by Liechtenstein's national tax administration serves as

the base quantity. To figure up the share of income of self-employees' the AHV-proxy is applied. The same proxy as explained in the previous sub-chapter yields the ratio of labour income of employed versus self-employed people. It basically is the difference of the total labour income and the compensation of employees, the latter has been calculated earlier. TABLE 7 displays the calculated figures of the entrepreneurial income of self-employees.

	CHF	1993	1994	1995	1996	1997	1998
	Labor Income	1'001'122'000	1'048'656'000	1'094'324'000	1'131'949'000	1'200'275'000	1'248'350'101
*	Share Self-Employees	0.0513	0.0438	0.0445	0.0443	0.0425	0.0393
=	Income Self-Employees	51'328'571	45'943'396	48'653'216	50'166'622	51'061'420	49'060'159

TABLE 7: Entrepreneurial Income of self-employees

1.3.1.3. Property Income of Private Households

Not only the labour income but also the property income is an important part of the national income account. The property income of private households consists of four components: interest income plus dividend income plus rental income minus interest on debts from consumption loans. Most important data sources are the national income statement in the annual governmental report, the income statement in the annual reports of the municipalities, the income statements of the social insurances, the Statistical Yearbook and figures compiled by the national tax administration.

To obtain an approximative estimate of the *interest income,* the interest income of the municipalities, the state and the social insurances have to be subtracted from the interest income of the residents in order to obtain the interest income of the private households (as listed in TABLE 8)[11]. While the interest incomes of the state, of the municipalities and of the social insurances can be simply summed up from their income statements, the computation of the residents' interest income is more

[11] From now on, all the figures in *italics* denote rough approximations by the author due to gaps in the data sources.

involved (as explained in the appendix 1.A.1.). The returns on capital of the following social insurances are accounted for: Public pension, widow(er) and orphan insurance (Alters- und Hinterlassenenversicherung, AHV), invalidity insurance (Invalidenversicherung, IV), family benefits (Familienausgleichskasse, FAK), unemployment insurance (Arbeitslosenversicherung, ALV), obligatory health insurance (Obligatorische Krankenversicherung, OKV), occupational compensation insurance (Berufsunfallversicherung, BUV) and private pension insurances. The interest income of the private pension insurances was compiled by the Office of Economic Affairs but is, however, confidential. So, the detailed compilation of the interest income of the insurances quoted before cannot be displayed here.

	Interest Income (in CHF)	1993	1994	1995	1996	1997	1998
	Residents	367'395'195	328'303'656	304'583'958	184'824'464	168'843'224	154'437'092
-	**Municipalities**	*3'000'000*	2'918'069	2'163'650	1'810'182	2'334'620	1'849'386
-	**State**	13'473'236	4'561'944	10'741'152	13'294'457	11'477'091	18'646'877
-	**Social Insurances**	34'500'450	31'468'097	30'889'544	48'033'045	57'458'438	42'794'603
=	**Interest Income TOTAL**	316'421'509	289'355'546	260'789'612	121'686'781	97'573'075	91'146'225

TABLE 8: Interest income of private households

The *dividend income* is calculated by subtracting the undistributed entrepreneurial income (undistributed profits) from the corporation's total profits, as visible in TABLE 9. Also the dividends of the shares of Liechtensteinische Landesbank (LLB) owned by the state have to be subtracted, since it is a part of the income of the state (property and entrepreneurial income of public sector, which is explained later on). The undistributed income and the profits are compiled by the tax administration and the dividend of the LLB is mentioned in the annual governmental report.

	Dividend Income (in CHF)	1993	1994	1995	1996	1997	1998
	Corporations' Profits	553'179'000	557'988'155	560'044'098	591'180'138	735'580'950	761'409'832
-	**Undistributed Profits**	277'862'000	249'137'278	220'802'209	244'527'706	267'892'194	319'821'584
-	**Dividend LLB**	28'800'000	28'800'000	32'000'000	35'200'000	36'250'000	36'400'000
=	**Dividend Income TOTAL**	246'517'000	280'050'877	307'241'889	311'452'432	431'438'756	405'188'248

TABLE 9: Dividend income of private households

The *rental income* of private households has to be approximated, since data on the real estate market in Liechtenstein is scarce. The census that is carried out every ten years by the Office of Statistics provides data such as the number of flats and the average rental price. Both figures are linearly interpolated between 1990 and 2000 and then multiplied in order to get the estimated aggregate rental income. The results are shown in TABLE 10.

	Number/CHF	1993	1994	1995	1996	1997	1998
	Number of Flats	3'364	3'467	3'571	3'675	3'778	3'882
*	Average Rental Price	11'810	12'223	12'636	13'049	13'462	13'874
=	Rental Income	39'727'824	42'382'724	45'123'156	47'949'120	50'860'617	53'857'646

TABLE 10: Rental income of private households

The interests on debts from consumption loans have to be subtracted, after the interest income, the dividend income and the rental income have been compiled and summed up. These interests are not known and must be approximated, the numbers here are taken from the original approximation of the financial unit of the government.

Property Income (in CHF)		1993	1994	1995	1996	1997	1998
	Interest Income	316'421'509	289'355'546	260'789'612	121'686'781	97'573'075	91'146'225
+	Dividend Income	246'517'000	280'050'877	307'241'889	311'452'432	431'438'756	405'188'248
+	Rental Income	39'727'824	42'382'724	45'123'156	47'949'120	50'860'617	53'857'646
-	Interests on Debts	5'340'000	4'728'000	4'149'000	4'267'000	4'287'000	*4'200'000*
=	Property Income	557'098'509	564'678'423	563'882'501	428'872'213	524'724'831	492'134'473

TABLE 11: Property income of private households

All the relevant components that have just been outlined are aggregated and shown in TABLE 11 above.

1.3.1.4. Undistributed Income of Corporate Enterprises

After having compiled the labour and property income of private households, also the corporations have to be considered. The undistributed income of corporate enterprises consists of both private and public corporations. It is essentially the private corporations' profits minus the private corporations' payouts plus the public corporations' profits. The difference of private corporations' profits and the undistributed incomes of private corporations represent the same amount which has also been implemented in the calculation of the dividend income of the private households earlier.

The data for the privately owned corporations can be obtained from the national tax administration while the figures referring to the publicly owned corporations are taken from Liechtenstein's income statement in the annual governmental report. As shown in TABLE 12, the considered public corporations are: the national gas supplier (Liechtensteinische Gasversorgung, LGV) and the national energy supplier (Liechtensteinische Kraftwerke, LKW).

CHF	1993	1994	1995	1996	1997	1998
Undistributed Income Corporate Enterprises	278'984'125	250'468'175	222'133'415	246'602'758	269'610'542	322'697'337

TABLE 12: Undistributed income of corporations

1.3.1.5. Direct Taxes of Corporate Enterprises

The direct taxes of the corporate enterprises have to be added to their undistributed income. The position "direct taxes of corporate enterprises" can be determined by simply considering the aggregated raised taxes on capital and on profits (Kapital- und Ertragssteuern), which are annually published by Liechtenstein's tax administration. TABLE 13 shows the direct taxes for each year.

CHF	1993	1994	1995	1996	1997	1998
Direct Taxes	43'296'273	59'702'706	69'000'786	70'753'592	74'219'418	86'008'162

TABLE 13: Direct taxes of corporate enterprises

1.3.1.6. Property and Entrepreneurial Income of Public Sector

The property and entrepreneurial income of the public sector includes all interest incomes from leasing, renting and capital received by the state and the municipalities. They are published in the individual income statements of the municipalities and in the national income statement along with the annual governmental report. The different book-entry items referring to any kind of property and entrepreneurial income are summed up for each municipality and for the state. This is shown in TABLE 14.

	CHF	1993	1994	1995	1996	1997	1998
	Income on Leasing/Renting (Municipalities)	*4'000'000*	4'111'247	4'737'086	5'399'820	5'769'025	*6'000'000*
+	**Income on Leasing/Renting (State)**	681'053	734'409	664'520	632'990	652'157	633'224
+	**Income on Capital (Municipalities)**	*3'000'000*	2'918'069	2'163'650	1'810'182	2'334'620	1'849'386
+	**Income on Capital (State)**	42'933'236	34'021'944	43'401'152	49'154'457	49'911'765	55'706'877
=	**Income of Public Sector**	50'614'290	41'785'669	50'966'408	56'997'449	58'667'567	64'189'486

TABLE 14: Property and entrepreneurial income of public sector

1.3.1.7. Interest on Debt of Public Sector

From the interest incomes (previous position from the sub-chapter 1.3.1.6.) all the interests on debt by the public sector have to be subtracted. Again, relevant figures can be obtained and aggregated from the individual income statements of the

municipalities and the national income statement in the annual national governmental report. TABLE 15 lists the interest on debt of the public sector.

	CHF	1993	1994	1995	1996	1997	1998
	Interest on Debt (Municipalities)	*1'600'000*	1'532'107	1'716'379	1'374'475	924'974	627'860
+	Interest on Public Debt (State)	5'788'724	5'689'900	5'527'091	4'602'358	3'984'373	3'905'472
=	Interest on Debt of Public Sector	7'388'724	7'222'007	7'243'470	5'976'833	4'909'347	4'533'332

TABLE 15: Interest on debt of public sector

1.3.1.8. Property and Entrepreneurial Income of Social Insurances

Also the interests gained and paid by the social insurances are to be considered within the national income accounts. These included social insurance institutions are public pension/widow(er)/orphan insurance, invalidity insurance, family benefits, unemployment insurance, obligatory health insurance, occupational accident insurance, pension funds for employees of the state and private pension funds.

The relevant numbers can be found in the income statements of the annual reports of the respective social insurances. TABLE 16 may not be broken down into more detailed figures, since some of the data are confidential, for example the detailed data regarding the private pension funds.

	CHF	1993	1994	1995	1996	1997	1998
	Income on Leasing/Renting	*4'009'864*	4'586'792	5'302'871	6'605'808	6'403'047	6'085'118
+	Interest on Capital	*115'001'358*	104'893'656	102'965'262	160'110'148	191'528'160	142'648'678
-	Interest on Debt	*5'065'721*	5'029'206	6'456'588	5'759'248	7'822'112	2'912'551
=	Property and Entrepreneurial Income of Social Insurances	113'945'501	104'451'242	101'811'545	160'956'708	190'109'095	145'821'245

TABLE 16: Property and entrepreneurial income of social insurances

1.3.1.9. Addition to Entire National Income Account

After having compiled all the sub-components, they can be totalled to the first approximation of national income, which serves as an indicator to chain both periods 1993-1998 and 1998-2009 (the latter provided by the national accounts) to one continuous time series. The following table summarizes all the sub-components and their annual totals outlines earlier.

	Sub-Accounts (in CHF)	1993	1994	1995	1996	1997	1998
	Compensation of Employees	1'107'149'506	1'170'189'674	1'220'025'931	1'264'149'251	1'345'131'511	1'405'167'249
+	Entrepreneurial Income of Self-Employees	51'328'571	45'943'396	48'653'216	50'166'622	51'061'420	49'060'159
+	Property Income of Private Households	596'826'332	607'061'147	609'005'657	476'821'333	575'585'448	545'992'119
+	Undistributed Income of Corporate Enterprises	278'984'125	250'468'175	222'133'415	246'602'758	269'610'542	322'697'337
+	Direct Taxes of Corporate Enterprises	43'296'273	59'702'706	69'000'786	70'753'592	74'219'418	86'008'162
+	Property/Entrepreneurial Income of Public Sector	50'614'290	41'785'669	50'966'408	56'997'449	58'667'567	64'189'486
-	Interest on Debt of Public Sector	7'388'724	7'222'007	7'243'470	5'976'833	4'909'347	4'533'332
+	Property/Entrepreneurial Income of Social Insurances	113'945'501	104'451'242	101'811'545	160'956'708	190'109'095	145'821'245
=	National Income (Indicator)	2'234'755'873	2'272'380'001	2'314'353'487	2'320'470'881	2'559'475'655	2'614'402'426

TABLE 17: Summing up the indicator for national income

The annual percentage change of the national income indicator is used for the backward-calculation starting with the national income of the year 1998 that is issued by the official national accounts. The underlying reasonable assumption is that the relative change of the actual national income can be approximated by the national income indicator.[12]

[12] It is not possible to evaluate this (yet very reasonable) claim, since some important data sources needed are confidential or not accessible. Otherwise, the calculation method could also have been carried out for the years 1999-2009 in order to compare the growth rates with those from the official national accounts. Additionally, carrying out the method also for the years 1999-2009 would be highly time-consuming and even more complex (if not impossible) than for the years 1993-1997, where at least some of the data sources have already been compiled and been exceptionally made accessible to the author by national authorities.

Mio. CHF	1993	1994	1995	1996	1997	1998
National Income (Indicator)	2'234.8	2'272.4	2'314.4	2'320.5	2'559.5	2'614.4
%-Change (Retropolation)		+1.68%	+1.85%	+0.26%	+10.30%	+2.15%
National Income	2'459.6	2'501.1	2'547.3	2'554.0	2'817.0	2'877.5

TABLE 18: Backward computation of national income by applying the derived indicator

FIGURE 2 gathers the five annual observations that have just been derived (and listed in TABLE 18) together with the already existent official figures by the national accounts from 1998 to 2009 into one combined time series for Liechtenstein's national income, as well in real (deflated with the Swiss GDP deflator) as in nominal terms.

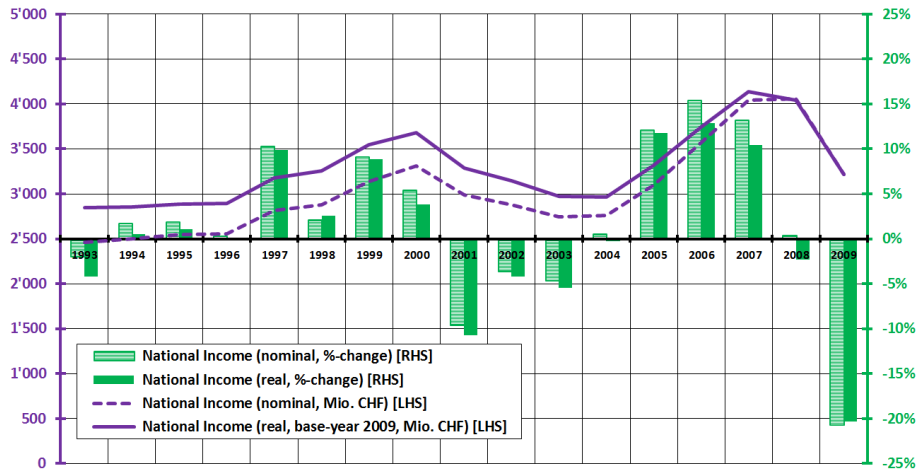

FIGURE 2: Real and nominal national income of Liechtenstein

A short economic interpretation supports the plausibility of the calculated growth rates of national income from 1994 to 1998. Influences worth mentioning and potentially leading to the observed business cycle pattern are the Asia-Crisis in 1998, the world-wide boom by the end of the 90s and the world recession in the first half of the 90s (which was accompanied by a restrictive monetary policy of the Swiss National Bank).

Besides the economic plausible interpretation of the absolute and relative values, also other indicators, such as the foreign sales of Liechtenstein's industry, Liechtenstein's exports of goods and the Swiss national income show a similar pattern: very moderate growth until 1996 and two considerable peaks of percentage

growth in the successive years. As it turns out, the generated growth rates of national income also correspond well with the final estimates of Liechtenstein's gross domestic product, which will be derived for the years before 1998 (in chapter 1.4.). FIGURE 3 shows the evolution of the national income and the gross domestic product in Liechtenstein, both in nominal terms.

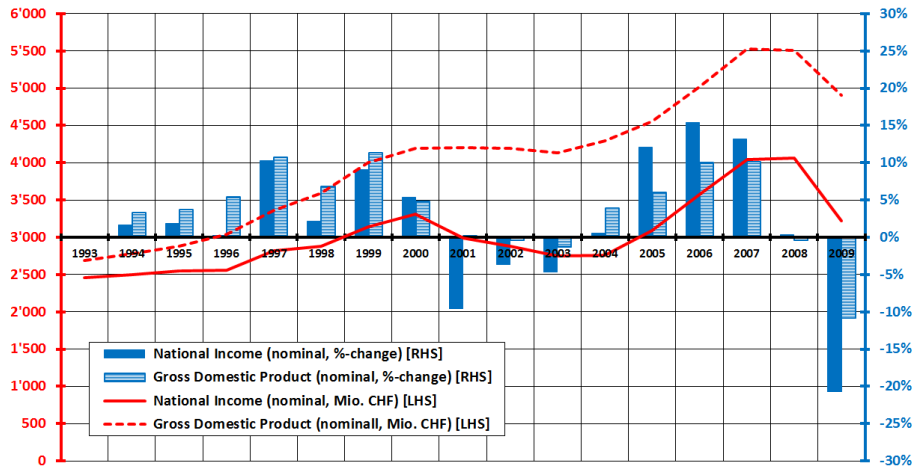

FIGURE 3: Nominal GDP and nominal national income of Liechtenstein

1.3.2. Backcasting: 1954-1992

As national income[13] figures are required in the calculation process for the GDP's sub-account "taxes on production and imports", the missing values are estimated here to fill the data gaps. FIGURE 4 displays the already available data points. The estimations are also valuable from an economic view as they generate an important economic time series for Liechtenstein from 1954 to 2009 without missing data for particular years.

As already noted, national income figures are required for some parts of the taxes on production and imports, according to the executed procedure of the official national accounts of Liechtenstein. This requirement holds for some of the different kinds of taxes on production and imports that are raised and processed by Swiss authorities. Liechtenstein shares a monetary and economic union with Switzerland in various aspects, for example the custom treaty with Switzerland and the Swiss Franc as common currency. The share of Liechtenstein out of the common pool of both countries regarding the relevant taxes and tariffs is calculated by different measures such as the number of inhabitants and/or the national income.

The previous chapter dealt with the direct calculation of national income figures for the years 1993-1997. Unfortunately, important data sources needed for this computation method are not available anymore or not accessible for the public. Thus, annual figures for the years before 1993 have to be obtained econometrically, applying a statistical model. The chart in FIGURE 4 visually gathers the different sources of national income figures which are available for the statistical estimation model. Four different data sources are disposable so far: The official national accounts (OFFICE OF STATISTICS [2011]), the figures by SCHNETZLER [1966] and KRANZ [1973] and the calculations done in the previous section.

[13] The exact definition of Liechtenstein's national income and the difference to the gross national income are explained in chapter 1.2. and 1.3.'s beginning.

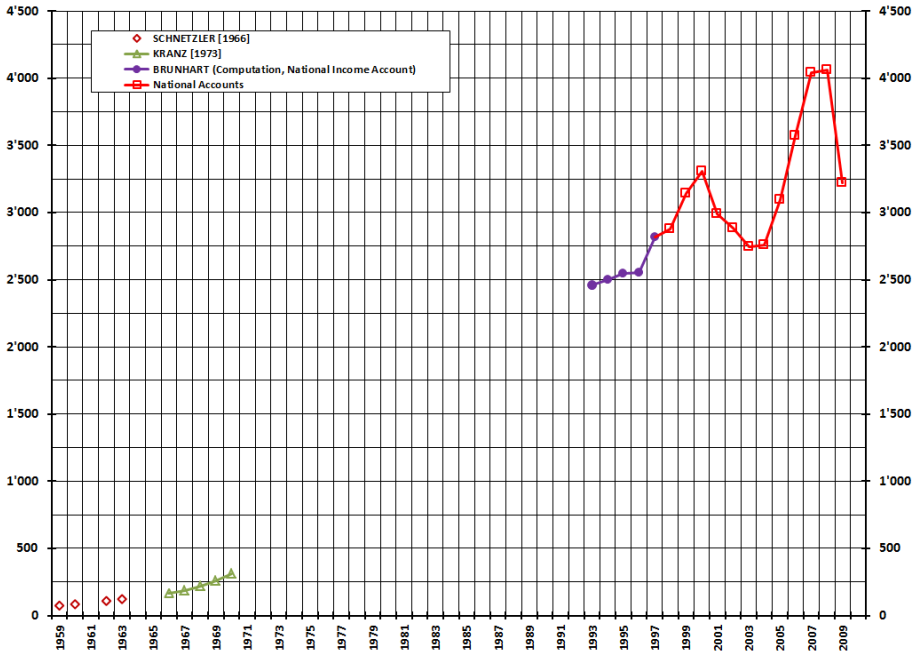

FIGURE 4: Observations for Liechtenstein's national income

Once all the figures of the national income for all the available years are gathered (1960, 1963, 1966-1970, 1992-2009), there are 27 years remaining for which estimated values shall be generated via the three following steps:

[1] *Approximative interpolation* (1959, 1961-1962, 1964-1965): There exist national income figures for 1959 and 1961-1962, which were calculated by BECK [1961 and 1963]. His approach is also outlined in OEHRY [2000, p.64-65]. Even though they principally follow the systematic of OECD [1958], the level of these numbers is not directly comparable with the numbers from SCHNETZLER [1966]. Yet, they are not heavily divergent. Additionally, it is well-grounded to assume that the relative annual percentage changes are comparable with the figures by Schnetzler. Therefore, the figures of Beck are adjusted and both sources combined in this dissertation's sub-project. This is done in a heuristic-iterative manner finding a balance between linear interpolation and the relative difference of the raw values for 1959, 1961 and 1962. The two years 1964 and 1965 are linearly interpolated in order to attain

a complete sub-sample from 1959-1970. These interpolated values are being replaced later on by the fitted values resulting from step [3].

[2] *Econometric estimation* (1954-1958, 1964-1965, 1971-1992): There are several economic data series, which are eligible as indicators for the backward-estimation of Liechtenstein's national income. The used series were chosen due to their correlation with national income in their levels and percentage changes (measured for those years with existing national income figures). The definitive decision whether a variable is included into the model or not mainly depends on its contribution to the predictive accuracy of the model. The applied estimation modelling approach shall be outlined in more detail later in this chapter. For the retropolation of the years 1954 until 1958 the predicted figures are directly applied by the backward application of the fitted values (differenced logarithms). For the interpolation of the other two time periods 1964-1965 and 1971-1992, the fitted values are subject to adjustments, as explained in step [3].

[3] *Interpolative correction of estimation* (1964-1965, 1971-1992): The estimated values from the estimation model of step [2] are now weighted by an adjustment factor to assure a better corresponding with the difference of the level (thus, the long-term growth) of the observed values of 1963 compared to 1966 and 1970 relative to 1993. These adjustment factor weights are generated by the linear interpolation of the ratios at the beginning and at the end of both time frames 1964-1965 and 1971-1992. The ratios are calculated by dividing the fitted value from [2] with the observed values of SCHNETZLER [1966], KRANZ [1973] and of the computed figures from the previous chapter.

For the steps [2] and [3] several indicator series, which are related to national income, are involved. The four chosen indicator series are the wages in

Liechtenstein[14], the banking assets in Liechtenstein[15], the foreign sales of Liechtenstein's main industrial companies[16] and the gross national income of Switzerland. These data series have been selected out of about 30 economic time series according to their correlation to Liechtenstein's national income (for the years with national income data available). They are obtained from the annual Statistical Yearbook by the national statistical office (OFFICE OF STATISTICS [2012a]), except for the Swiss national income[17] which is published by Swiss Statistics (http://www.bfs.admin.ch). Some of the series have been corrected by the author for structural changes or outliers. Also, some data gaps have been filled using other archived data sources.

There are two main reasons, why the nominal national income is used instead of the real national income: In the official national accounts, only nominal values are published, since no official price indices exist for Liechtenstein. Also, all the considered indicator series are measured in nominal terms (Swiss Francs), too.

Correlation (1959-1970, 1993-2009)		Wages	Banking Assets	Foreign Sales	GNI Switzerland
National Income Liechtenstein	Level (log)	0.9967	0.9987	0.9953	0.9978
	Growth Rates (dlog)	0.5907	0.7836	0.8115	0.4242

TABLE 19: Correlation of national income and indicators

The table above shows the correlation coefficients of the included independent variables with the dependent variable (national income), in levels and growth rates (logarithms and differenced logarithms). The rather low correlation of

[14] All the wages and self-employed incomes in Liechtenstein, which are relevant for the public pension insurance (Alters- und Hinterlassenenversicherung, AHV) are included. All employees have to contribute to the AHV. All employees' aggregated incomes, which are subject to these contributions, are collected and published by the AHV. Also self-employees have to contribute to the public pension system. These aggregated self-employees' incomes are collected and published as well by AHV.

[15] These numbers are collected by Liechtenstein Bankers Association (Liechtensteiner Bankenverband, LBV) and include the assets of the balance sheets of all banks located in Liechtenstein.

[16] The foreign sales are compiled by Liechtenstein Chamber of Commerce and Industry (Liechtensteinische Industrie- und Handelskammer, LIHK). The members of the chamber are included, they consists of all the companies in Liechtenstein of significant size and importance.

[17] Different sources for different years have been harmonized and chained by the author.

Liechtenstein's national income and Switzerland's gross national income is due to an outlier in the year 2009. However, the correlation of the growth rates exceeds 0.7 if that particular year is excluded.

For the six considered series, unit root tests have been conducted. An augmented Dickey-Fuller test (DICKEY AND FULLER [1979]) with one-sided p-values after MACKINNON [1996] was applied using the test strategy proposed by ELDER AND KENNEDY [2001] and the information criterion by AKAIKE [1974] for the determination of the lag order in the estimation setting shown below:[18]

$$X_t = \alpha + \delta \cdot t + \phi \cdot X_{t-1} + \gamma_1 \cdot \Delta X_{t-1} + \ldots + \gamma_p \cdot \Delta X_{t-p} + \varepsilon_t$$

The deterministic regressors are the constant α and the linear time trend t, whereas the coefficient ϕ from the autoregressive component is of main importance and is equal to one in the case of a unit root. The lags of the differenced dependent variable (ΔX_{t-i}) represent the augmentation of the augmented test. The estimated test equation below can be derived by subtracting X_{t-1} from both sides of the equation above:

$$\Delta X_t = \alpha + \delta \cdot t + \underbrace{(\phi - 1)}_{\beta} \cdot X_{t-1} + \gamma_1 \cdot \Delta X_{t-1} + \ldots + \gamma_p \cdot \Delta X_{t-p} + \varepsilon_t$$

$$\text{H}_0\text{: } \phi = 1 \text{ (tested via H}_0\text{: } \beta = 0\text{)}$$

TABLE 20 shows the results of the conducted unit root tests. The null-hypothesis of the existence of a unit root cannot be rejected for the level of all the series, but for the annual differences of all the series.

[18] For the justification of the chosen approach also see NEUSSER [2006, p.112-115].

ADF-Tests	Constant α	Trend t	Lags (AIC)	β (t-Value / p-Value)	I(d)
log(*NATIONAL INCOME*)	Yes	Yes	4	0.1749/0.9956	**I(1)**
dlog(*NATIONAL INCOME*)	Yes	Yes	3	-7.0380/0.0001	
log(*WAGES*)	Yes	Yes	5	-0.5812/0.9759	**I(1)**
dlog(*WAGES*)	Yes	Yes	4	-5.3906/0.0003	
log(*FOREIGN SALES*)	Yes	Yes	4	0.4582/0.9989	**I(1)**
dlog(*FOREIGN SALES*)	Yes	No	3	-3.8929/0.0040	
log(*BANKING ASSETS*)	Yes	Yes	4	-0.4822/0.9814	**I(1)**
dlog(*BANKING ASSETS*)	Yes	Yes	4	-6.4019/0.0000	
log(*GNI CH*)	Yes	Yes	2	-2.3884/0.3813	**I(1)**
dlog(*GNI CH*)	Yes	Yes	1	-6.5487/0.0000	

TABLE 20: Unit root tests for the applied variables

The unit root tests show that all the used series are I(1), meaning that they are integrated of order one. These findings are also supported by other unit root/stationarity tests, such as the tests after PHILLIPS AND PERRON [1988] and KWIATKOWSKI ET AL. [1992]. Thus, in order to avoid the danger of spurious regression, variables are being differenced to obtain stationarity.

GRANGER AND NEWBOLD [1974] pointed out the potential problem and consequences of spurious regression. According to them, it may lead to falsely low p-values and high R^2. The Durbin-Watson test checks the presence of serial correlation of first order among the errors of the model and was introduced by DURBIN AND WATSON [1950]. Especially the high R^2 indicates the likely presence of spurious regression if the variables are used in log-levels. But then again, the main purpose is the interpolation-task and not the decision about the significance of individual variables (the latter is of main concern along with spurious regression).

Since this project mainly serves as an interpolation method, models are chosen in order to maximize the predictive accuracy and do not deal with the individual variables and their individual significance and the linked economic hypotheses and conclusions. Therefore, different specifications applying the variables also in log-levels are evaluated, as well. The log-level models include a linear trend and a lagged term for the dependent variable in order to remove the residual's autocorrelation. Still, the results from the regression in log-levels of the non-stationary data should

be handled with care since the predictions in the interpolated sub-sample are dynamic and not static forecasts, because coefficients of the lagged dependent variable correspond to the national income figure one period ago (that has also been fitted). To a certain extent, this remark also holds for the model in log-differences, as the reference value of the dependent variable's level, to which the estimated value in differences relates, consists of an already forecasted value.[19] The chosen models of both kinds and their estimated parameters are shown in TABLE 21 and TABLE 42.

Another approach to deal with non-stationary data would be to use an error-correction model[20], either in a univariate framework after ENGLE AND GRANGER [1987] or in a multivariate setting in the tradition of JOHANSEN [1988]. These models incorporate a stationary cointegrating relationship between the variables in levels. They also include some error correction adjustment term if the system temporarily deviated from the long-term equilibrium and also short-term dynamics modelled as a vector autoregression of the differenced variables (and possibly some deterministic regressors in the different components within the whole error-correction model). But, in the application here, there are only few degrees of freedom for the estimation of the rather complex error-correction model and there is no continuous sample. This is why no error-correction model has been executed.

The following measures played an important role in the decision about the potential inclusion of variables and deterministic regressors (trend and time dummies) but also in the context of choosing the appropriate lag length of the independent and dependent variables:[21]

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[19] Even though the chosen dlog-model can only produce static and no dynamic forecasts (no lagged terms are involved), it generates dynamic predictions in the interpolated sub-sample when the values are transformed from log-differences into log-levels.

[20] For more details on (vector) error-correction models see LÜTKEPOHL [2005] or ASTERIOU AND HALL [2007].

[21] Due to the small sample size, the upper bound for the applied individual lag lengths of the variables was chosen to be two. As it turns out, the lags of any of the variables do not improve the model according to the here mentioned measures in the setting using log-differenced variables. One lag of the dependent variables has been included into the setting with log-levels of the variables.

- *Goodness-of-fit*: The adjusted R^2 and information criteria such as the ones after AKAIKE [1974] or SCHWARZ [1978] have been consulted in the model specification process. Yet, the main focus has been on Akaike's information criterion.

- *Significance of coefficients*: The significance of the included variables and the additional deterministic regressors has been checked, whereas the insignificance of a coefficient was in general not yet a sufficient reason for excluding this lag or variable.

- *Residuals*: The residuals have been checked for severe outliers and if there is remaining autocorrelation of the model's residuals left. The examination of the autocorrelation is done via plotting the residual's correlogram and through the residual tests of LJUNG AND BOX [1978] and of BREUSCH [1978] and GODFREY [1978].

- *Prediction error*: The mean percentage prediction error (in-sample) has also been considered. For each predicted value, the percentage deviation from the actual value has been computed and squared. The average of the square roots of these deviations represents the (mean) absolute prediction error. This evaluation is, of course, related to the Akaike's information criterion that was mentioned before. The percentage error was given the main priority compared to the significance of the coefficients or the goodness-of-fit measures.

- *Confidence interval*: The average of the size of the confidence intervals, measured as standard errors relative to the predicted value of each year, for all the fitted values has been calculated and serves as an additional judgement of predictive accuracy.

These measures have been considered in the specifications for both of the models in logs and in dlogs. Comparing the predictive accuracy of the best specifications of both types, it turns out that the dlog-specification is superior to the log-specification. Indications leading to this conclusion are that the dlog-model features a considerably lower prediction error (1.92% versus 2.36%) and that the average confidence interval is smaller (average reliability indicator[22] of 6.16% against 8.05%).[23] Even though information criteria can be applied for the comparison of the accuracy of different nested and non-nested models, they may not be used to compare equations with different dependent variables. Thus, while these criteria are used for finding the best specification within the two kind of models (log and dlog), they are not used for the comparison of the best log-specification versus the best dlog-specification. Also, the comparison of the adjusted R^2 is not of big use, since the log-model exhibits such a high R^2, because it incorporates non-stationary variables with a positive trend.

The estimation output of the chosen predominant model is shown in TABLE 21, whereas their fitted and actual values are illustrated in FIGURE 5:

Dependent Variable: dlog(*NATIONAL INCOME*)		Sample (adjusted): 1960-2009		
Method: Least Squares		Included Observations: 27 after adjustments		
Variable	**Coefficient**	**Standard Error**	**t-Statistic**	**p-Value**
LINEAR TREND	-0.0010	0.0002	-5.7714	0.0000
dlog(*WAGES*)	0.3936	0.1252	3.1437	0.0051
dlog(*FOREIGN SALES*)	0.6411	0.0793	8.0852	0.0000
dlog(*BANKING ASSETS*)	0.4362	0.1083	4.0266	0.0007
dlog(*GNI CH*)	-0.7458	0.1705	-4.3733	0.0003
D61	-0.1031	0.0308	-3.3468	0.0032
D0506	0.0909	0.0218	4.1693	0.0005
Measures of Fit				
R-squared	0.9338	Mean Dependent Variable	0.0626	
Adjusted R-squared	0.9140	S.D. Dependent Variable	0.0930	
S.E. of Regression	0.0273	Akaike Info Criterion	-4.1462	
Sum Squared Residuals	0.0149	Schwarz Criterion	-3.8103	
Log Likelihood	62.974	Durbin-Watson Statistic	2.4022	

TABLE 21: Applied model for the interpolation

[22] The reliability indicator for every time point is measured by the percentage size of the confidence interval relative to the point forecast.

[23] The predicted values of the model in logs and of the model in dlogs are both transformed into (non-logarithmic) levels before the comparison takes place.

In general, it is not useful to display the information criteria if the output of only one estimation equation is being inspected. Yet, it is still shown here in order to highlight their importance during the specification process picking the involved variables, the time trend and time dummies. The estimation output shows that all included parameters are highly significant. In addition, the Lagrange-Multiplier test of BREUSCH [1978] and GODFREY [1978] and also the Q-test after LJUNG AND BOX [1978] do not reject the null-hypothesis of the non-existence of residuals' serial correlation. The estimation output also shows that two time dummies have been introduced, for the year 1961 and the time span 2005-2006. Also, a linear time trend is included. These inclusions are supported by lower prediction errors, better information criteria, significant coefficients, higher adjusted R^2 and visual economic discovery of outliers (regarding the time dummies) and by the fact that the growth rates are diminishing in average over time (regarding the time trend). With respect to the just mentioned attributes, no constant has been incorporated.

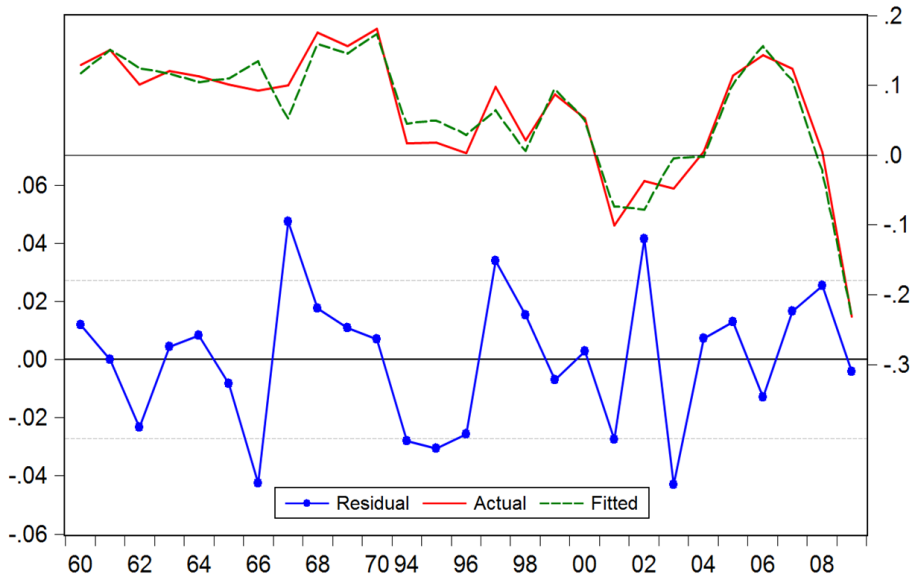

FIGURE 5: Actual and fitted values of national income (dlogs)

The following three plots of FIGURE 5 and FIGURE 6 show the actually observed values of Liechtenstein's national income, the estimated fitted values of the model and the resulting residuals. The predictive accuracy is satisfactory and does not indicate that the model should not be used for the interpolation. Also, the

confidence band of the predictions is continuously narrow during the whole time span of the forecasted sample.

The differenced logarithms of the fitted and actual values that are plotted in FIGURE 5 can be interpreted as growth rates, because they are approximately the percentage changes of the original series. FIGURE 6 shows the model's predicted and actual figures transformed into levels.

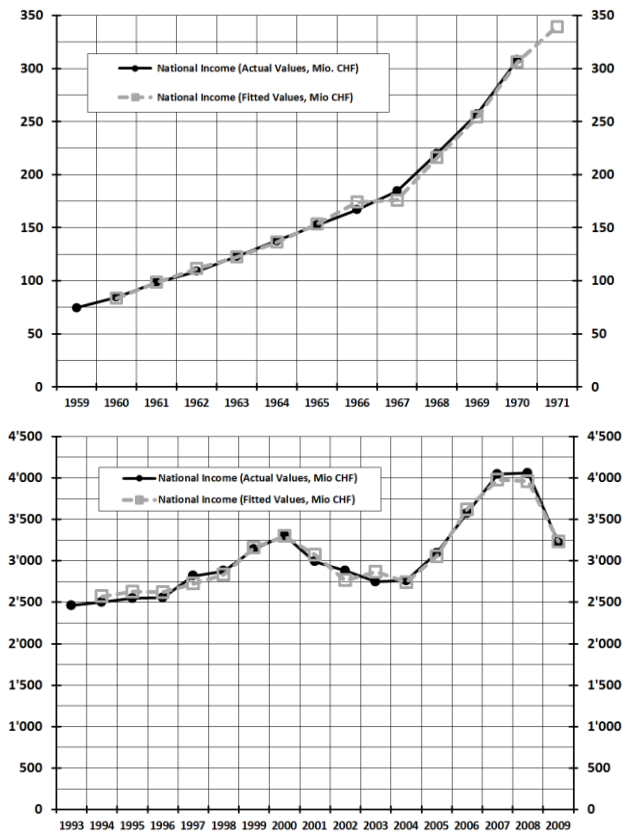

FIGURE 6: Predicted and actually observed national income

As the predominant estimation model has been found, the years with data gaps are now to be interpolated by the predicted values and weighted by the adjustment factor. TABLE 22 exhibits the already available data of Liechtenstein's national income and the newly generated values. The bold figures represent the final, chained time series for Liechtenstein's national income, the digits in *italics* are <u>estimations</u> by a heuristic interpolation or an econometric model. Those not in italics represent

approximative calculations according to the national income accounting scheme or represent official figures. The figures in the light-grey-layered cells are data gaps that have been filled by this sub-project of the dissertation (during the current and the previous sub-chapter). The table also shows the fitted values of the econometric model and the derived adjustment factors which were applied as weights for the dynamic interpolative adjustment.

National Income	Actual Value	Fitted Value	Adjustment Factor	Final Series	National Income	Actual Value	Fitted Value	Adjustment Factor	Final Series
1954		35.3		35.3	1982		786.0	1.5634	1'203.3
1955		42.0		42.0	1983		873.1	1.6098	1'265.3
1956		52.7		52.7	1984		83.7	1.6561	1'445.9
1957		61.2		61.2	1985		916.6	1.7025	1'560.5
1958		69.2		69.2	1986		980.8	1.7489	1'715.3
1959	74.4	83.7		74.4	1987		990.9	1.7953	1'779.0
1960	84.7	98.5		84.7	1988		1'040.8	1.8416	1'916.7
1961	98.5	111.5		98.5	1989		1'155.0	1.8880	2'180.6
1962	109.0	122.3		109.0	1990		1'146.8	1.9344	2'218.3
1963	122.9	136.5	1.0047	122.9	1991		1'147.6	1.9807	2'273.2
1964	137.6	153.6	0.9891	135.0	1992		1'237.6	2.0271	2'508.8
1965	152.3	174.3	0.9737	149.5	1993	2'459.6	1'186.3	2.0735	2'459.6
1966	167.0	175.9	0.9583	167.0	1994	2'501.1	2'572.1		2'501.1
1967	184.5	216.1		184.5	1995	2'547.3	2'626.7		2'547.3
1968	219.9	254.4		219.9	1996	2'554.0	2'620.5		2'554.0
1969	257.2	306.1		257.2	1997	2'817.0	2'722.9		2'817.0
1970	308.2	339.4	1.0070	308.2	1998	2'877.5	2'833.7		2'877.5
1971		357.3	1.0534	357.5	1999	3'138.7	3'160.7		3'138.7
1972		389.3	1.0997	392.9	2000	3'307.5	3'297.7		3'307.5
1973		424.9	1.1461	446.2	2001	2'989.1	3'072.7		2'989.1
1974		433.5	1.1925	506.7	2002	2'880.9	2'763.8		2'880.9
1975		481.8	1.2388	537.0	2003	2'746.7	2'867.6		2'746.7
1976		537.1	1.2852	619.3	2004	2'761.3	2'741.3		2'761.3
1977		550.2	1.3316	715.2	2005	3'094.9	3'055.4		3'094.9
1978		608.9	1.3779	758.2	2006	3'571.5	3'617.7		3'571.5
1979		695.6	1.4243	867.3	2007	4'043.3	3'977.2		4'043.3
1980		718.2	1.4707	1'023.0	2008	4'058.7	3'956.8		4'058.7
1981		769.7	1.5170	1'089.6	2009	3'221.6	3'235.0		3'221.6

TABLE 22: Estimation of Liechtenstein's national income (nominal, Mio. CHF)

The visual expression of the previous table is shown in FIGURE 7. The provided chained time series for Liechtenstein's nominal and real (deflated with the Swiss consumer price index) national income can now be used as important data series within the backward calculation of Liechtenstein's GDP and delivers important economic insights for Liechtenstein's growth characteristics and business cycle pattern.

The following empirical facts are evident at first sight when FIGURE 7 is inspected: Two phases with longer real stagnation can be detected during the first half of the 1970s and the first years of the 1990s. Both stagnations were consequences from deep and longer lasting recessions and not so much due to decreasing long-term

growth. But, lower economic long-run growth tendencies can be identified beginning with the end of the 1980s. Also, the sharp decreases can be traced at the start of the new millennium and also along with the financial crisis and the related global recession combined with the high insecurity in Liechtenstein's financial sector (Liechtenstein Tax Affair) in 2008 and especially in 2009.

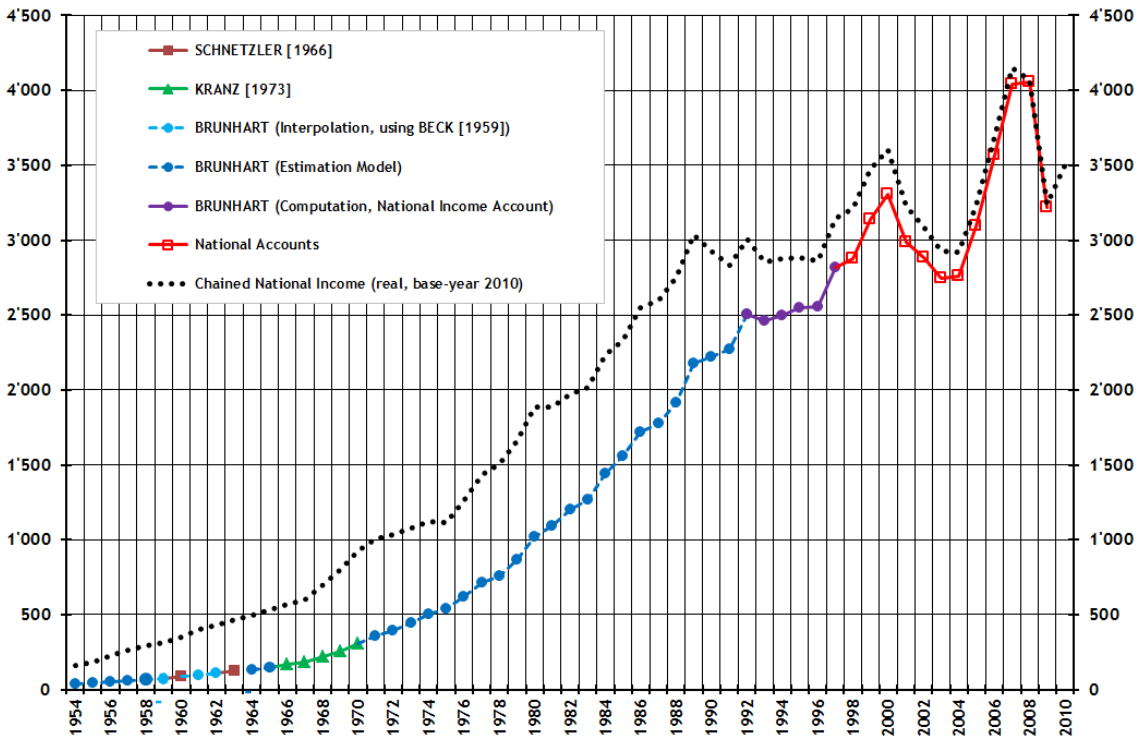

FIGURE 7: The finally chained time series for Liechtenstein's national income

The impression that the volatility has increased very much is mainly a result of the high change in the level of the national income over the time-span of the sample. Examining the growth rates, as shown in FIGURE 8, it becomes a priori unclear whether the volatility has increased or not. However, the cyclical amplitude measured as the percentage deviation from the real trend presumably has increased, as shown in FIGURE 10. Additionally, it seems that the sharpness of recessive down-turns has increased over time, even relative to the first oil-crisis in the mid-1970s.

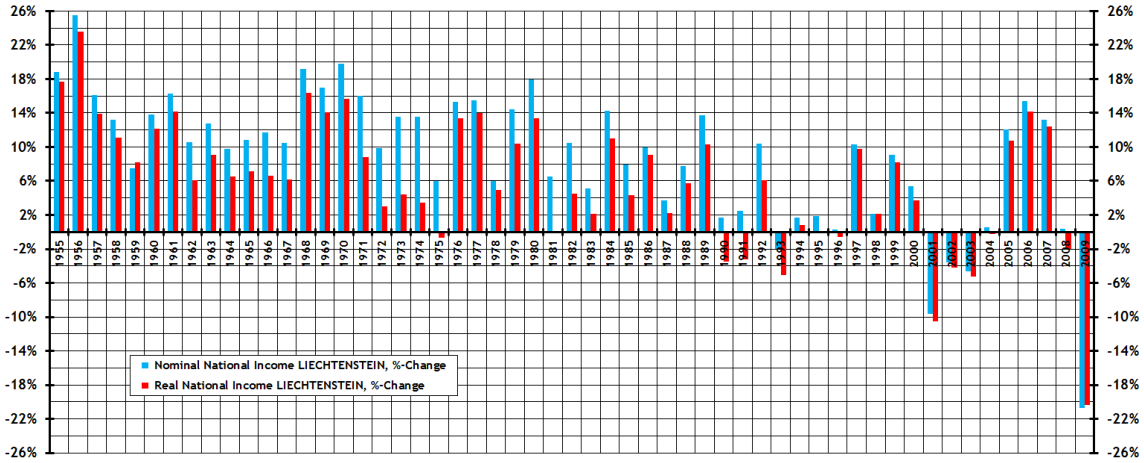

FIGURE 8: Nominal and real growth rates of Liechtenstein's national income

The visual inspection of the two previous figures supplies some economic insights: The first oil-price shock in the mid-70s and the restrictive monetary policy of the Swiss National Bank[24] in the first half of the 1970s are accompanied by weak economic performance. The Iranian Revolution and second oil-shock by the end of the 70s and the beginning of the 80s led to further recessive tendencies worldwide, which also influenced Liechtenstein's economy. Furthermore, the shocks on the stock markets in 1987 can be seen in the relatively low real growth rates. The war in Iraq and its consequences (sometimes labelled as „third oil-price shock") combined with the appreciation of the Swiss Franc led to a recession in the first half of the 90s in Switzerland and obviously also in Liechtenstein (see HARTWIG AND SCHIPS [2010, pp.53-77]). The Asia-crisis temporarily deteriorated the high economic growth during the last years of the 90s. Also clearly visible are the two world recessions of the new millennium. It is therefore reasonable to argue that the estimates generate an economically feasible business cycle pattern, which in addition is very similar to the business cycle pattern of Liechtenstein's GDP (as shown later on). The plausibility of the estimated business cycle pattern is also confirmed when the growth rates and the de-trended business cycle of Liechtenstein and Switzerland are compared.

[24] Liechtenstein is also part of the Swiss monetary system and has the Swiss Franc as official currency. The principality is therefore highly affected by the Swiss National Bank's decisions, regulations and policies.

A comparison of Liechtenstein's nominal national income time series with the time series of Switzerland also supports the plausibility of the growth pattern of the interpolated values (beyond the already verified cyclical archetype). This comparison not only yields methodological but also economic insights: Nominal national income in Switzerland rose between 1959 and 2009 from 22'873 CHF per capita to 56'999 CHF, while it increased in Liechtenstein from 16'018 to 90'146 CHF. In real terms, national income per inhabitant in Switzerland approximately doubled in the regarded time period and it increased approximately fourfold in Liechtenstein during the same time span. Especially the 80s were characterized by very strong real growth of Liechtenstein's potential output, as evident in FIGURE 9. The potential output is derived using the filter after HODRICK AND PRESCOTT [1997], which is usually called HP-filter.[25] Thus, the traditionally relatively poor principality could overtake its bigger neighbour in economic performance per capita. This took place during the 60s and the difference grew larger in the following decades, while trend-growths of both nations seem to have converged during the last twenty years.

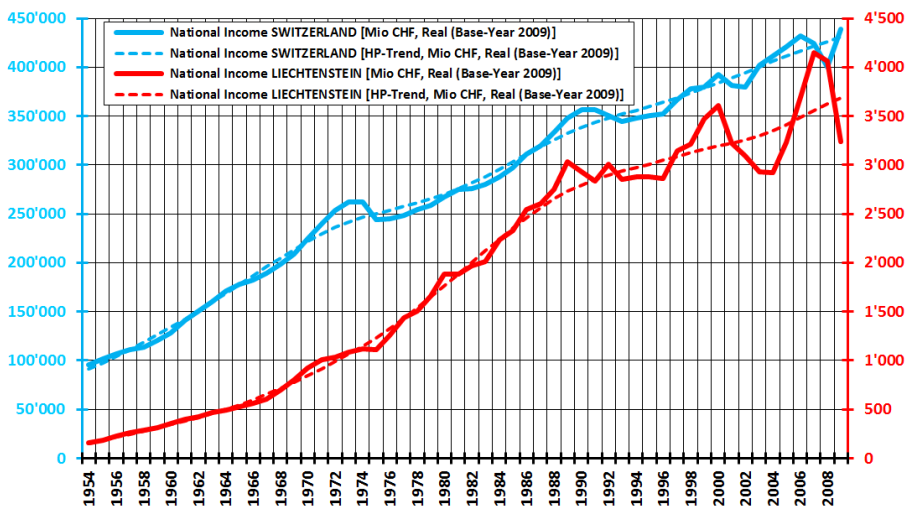

FIGURE 9: Real national income of Switzerland [LHS] and Liechtenstein [RHS] and their trend

Calculating the percentage difference of the observed values and the filtered series, the cyclical component, which captures the business cycle, can be identified. FIGURE 10 incorporates the business cycle pattern of both countries. Both cycles are

[25] For more explanations on the HP-filter see the appendix of chapter 2 (section 2.A.1.3.).

quite similar when it comes to locating the economic troughs and peaks. Yet, Liechtenstein's amplitude of the cycle is considerably higher than Switzerland's.[26]

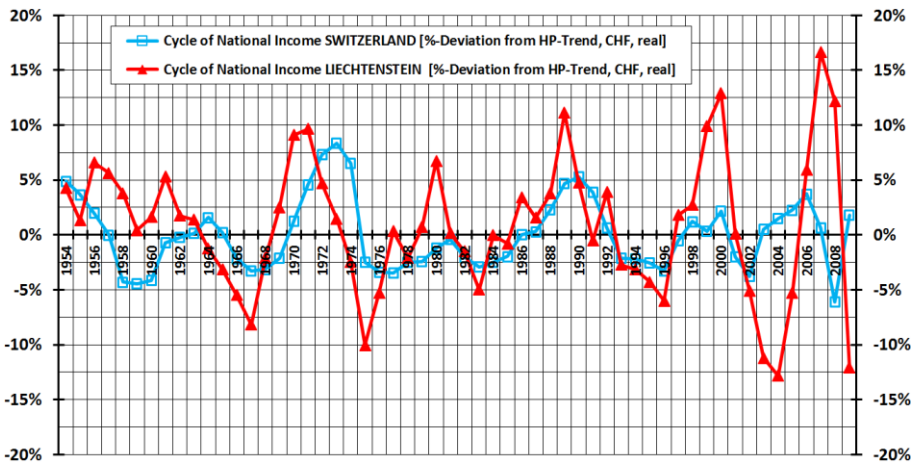

FIGURE 10: Cyclical Component of real national income in Switzerland and Liechtenstein

Another way of inspecting the reliability of the generated business cycle properties of the estimated and chained national income series is to compare it with the business cycle pattern of Liechtenstein's GDP, since both are highly correlated on theoretical grounds, which can also be regarded as a stylized fact in the empirics. The following graph in FIGURE 11 compares the growth rates of Liechtenstein's GDP and national income. The data for the growth rates originate from (preliminary)[27] estimates by the author of this dissertation, which have already been applied in BRUNHART, KELLERMANN AND SCHLAG [2012]: The GDP-years from 1954 to 1971 were estimated and retropolated applying an econometric model using indicators. The figures from 1972 until 1997 were calculated to be in line with Liechtenstein's national accounts. These figures were provisional and have been updated since and revised for the presentation of the finally revised estimates along with this dissertation (for details see chapter 1.4.). The growth rates of Liechtenstein's GDP and national income plotted in FIGURE 11 correspond to a very high extent. Assessed over the whole sample, they steadily correlate with a

[26] It also seems that the volatility of Liechtenstein's national income has increased over time. In contrast to the frequently advocated "great moderation"-thesis one could speak of a "great agitation" in the case of Liechtenstein.

[27] The final GDP-estimates are the main goal of this part of the dissertation.

correlation coefficient of about 0.83. In this light, the estimated figures for the national income appear to be very plausible.

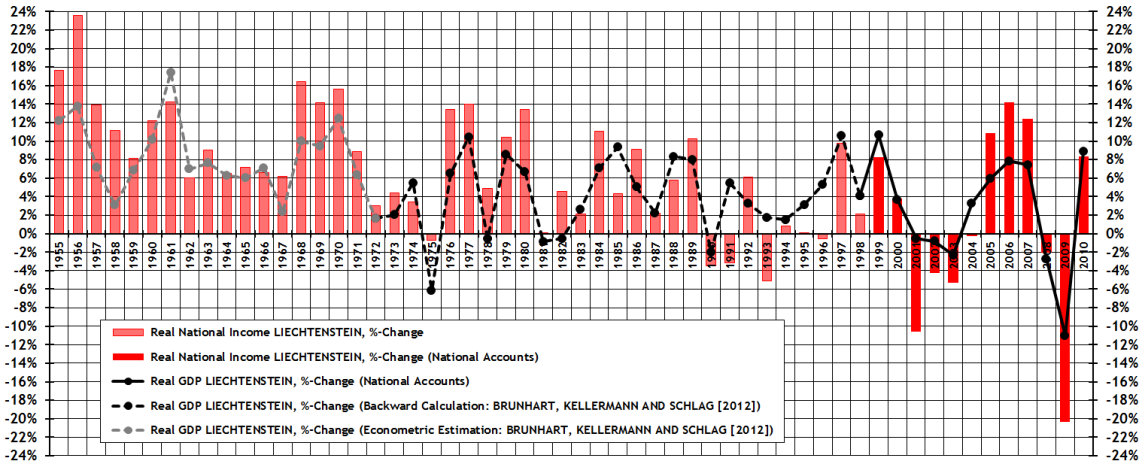

FIGURE 11: Real growth rates of Liechtenstein's national income and gross domestic product

Also, the de-trended cycles of both time series show that both business cycles are extremely similar. Again, the trend has been approximated by the HP-filter. The similarity in FIGURE 12 of the induced cyclical component of both aggregates, the national income and the gross domestic product, also supports the plausibility of the national income estimates.

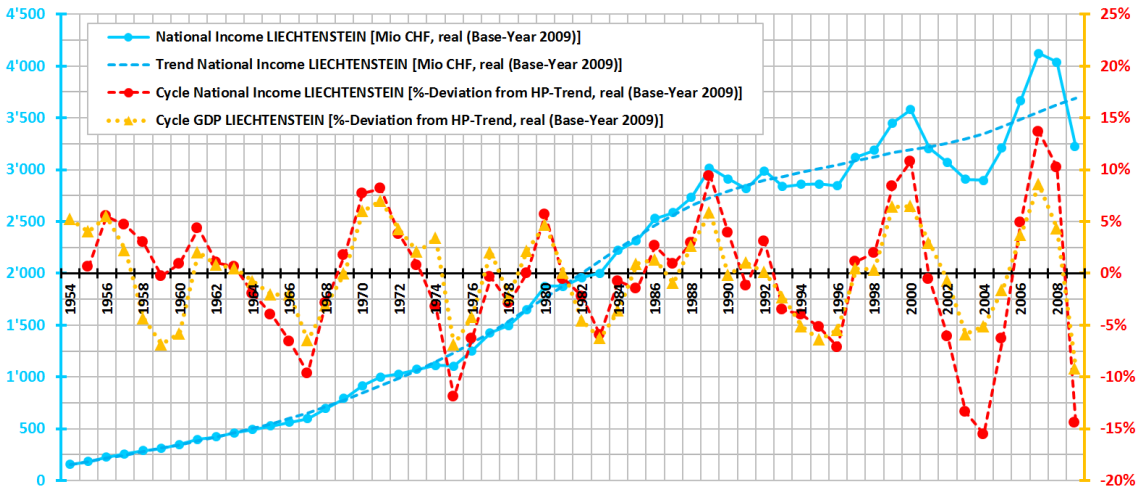

FIGURE 12: Cyclical component (deviation from HP-trend) of national income and GDP

It is valid to use both aggregates (which both also include approximated figures) for plausibility evaluations. Both series do not evolve from a similar econometric model

and are not solely a main function of only few data sources or just dependent on a very similar (potentially false) computation method. Figures for the national income in the 1960s mainly rely on calculations by SCHNETZLER [1966], BECK [1961 and 1963] and KRANZ [1973], while the GDP-figures of that period result from an econometric model with indicators. As stated earlier, the GDP-data 1972-1997 is calculated in this PhD-project with a deliberate and complex method approximating the GDP's income approach of the national accounts (as to be shown in chapter 1.4.). From 1971-1992, national income is estimated via the approach presented in this chapter and from 1993 until 1997 it is calculated to be approximately in line with the national accounting system, as explained in the previous chapter (1.3.1.). From 1998 on, both aggregates are published by the official national accounts. So, the estimation methods for both measures are independent from each other and are not dependent on a similar model with the same indicator series. The similarity is therefore not just an econometric artefact. Also, even though national income is one of dozens (or even hundreds) of sub-series included into the chosen calculation scheme of the GDP between 1972 and 1997, it only contributes very little to the variation and level of the final (total) GDP-figure.

The comparisons made here already confirmed at an already early stage the plausibility of the estimation/calculation for the removal of existing data gaps and the extension of the two important economic aggregates, the national income and gross domestic product of Liechtenstein.

1.4. GDP: Backward-Calculation and Prediction

As mentioned earlier, official data for the GDP of Liechtenstein are available only for the years 1998 until 2009. These GDP-figures have been published along with the official national accounts of Liechtenstein, provided in OFFICE OF STATISTICS [2011]. The SGZZ (St.Galler Zentrum für Zukunftsforschung) has carried out estimations of real and nominal GDP for the years 1960, 1970, 1975, 1980-1988 and 1991, on behalf of Liechtenstein's government. These estimations can be considered as rough estimations, since they were just a small part in those studies (see KNESCHAUREK AND GRAF [1990] and KNESCHAUREK AND PALLICH [1982]). Furthermore, they were based on estimated data of aggregated value added for different sub-sectors of the Swiss economy. It is questionable whether these numbers can be transferred to Liechtenstein and if this holds throughout the very long time span from 1960 up to 1991. Also, needed detailed employment data were not available (and surely not in such a detailed manner considering subsectors) for Liechtenstein in the 70s and for the first half of the 80s. Hence, the applied employment structures must have been rough approximations. Though, the SGZZ's method is not transparently explained in the relevant documents. Also, for any econometric analysis of economic matters, the time series need to be coherent and without data gaps. That is why there is an additional need for a new time series with estimated GDP figures. However, the figures by the SGZZ can still serve as a useful reference benchmark for the level of GDP in the 70s and 80s to the current GDP-estimation project carried out in this chapter.

There is a publication lag of almost two years in the official national accounts of Liechtenstein. This is due to the fact that Liechtenstein's government and authorities chose the least time-consuming procedure for the compilation and did not want to bother the companies with further bureaucracy. Doing so, the most important data is gathered from the national tax administration that in turn needs some time to annually collect the relevant tax information. That is why the

Liechtenstein Economic Institute (Konjunkturforschungsstelle Liechtenstein, KOFL) not only forecasts the GDP but also generates a "nowcast" of the missing past years (see SCHLAG [2012]). TABLE 23 lists all the available GDP-values for Liechtenstein.

	Gross Domestic Product (Nominal, in Mio. CHF)	**Calculated and published by**
1960	*136*	SGZZ
1965	*226*	SGZZ
1970	*394*	SGZZ
1975	*636*	SGZZ
1980	*896*	SGZZ
1981	*1'005*	SGZZ
1982	*1'060*	SGZZ
1983	*1'100*	SGZZ
1984	*1'181*	SGZZ
1985	*1'300*	SGZZ
1986	*1'402*	SGZZ
1987	*1'570*	SGZZ
1988	*1'700*	SGZZ
1991	(Not published)	SGZZ
1998	3'595.1	Office of Economic Affairs
1999	4'001.9	Office of Economic Affairs
2000	4'194.8	Office of Economic Affairs
2001	4'208.5	Office of Economic Affairs
2002	4'190.3	Office of Economic Affairs
2003	4'135.3	Office of Economic Affairs
2004	4'295.6	Office of Economic Affairs
2005	4'556.4	Office of Economic Affairs
2006	5'015.4	Office of Economic Affairs
2007	5'523.5	Office of Statistics
2008	5'495.0	Office of Statistics
2009	4'906.4	Office of Statistics
2010	*5'289*	KOFL
2011	*5'384*	KOFL

TABLE 23: Data and different sources of Liechtenstein's GDP

All the available years for the nominal GDP of Liechtenstein shown in TABLE 23 are visually displayed in FIGURE 13. The observations of 2010 and 2011 are estimations by KOFL and the value for 2012 is the most recent forecast (also by KOFL).

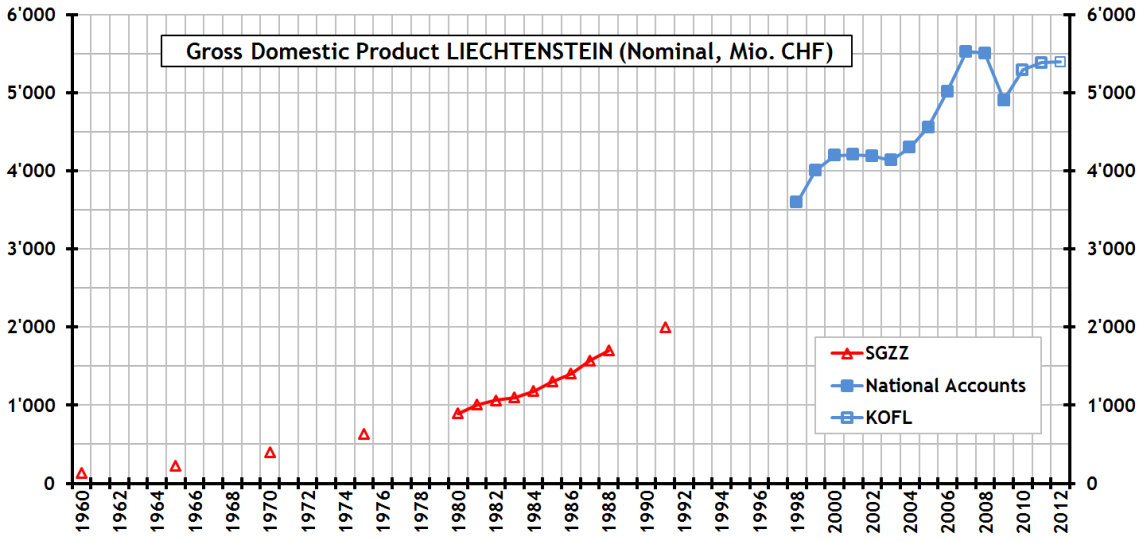

FIGURE 13: Available data points for Liechtenstein's GDP

The subsequently proposed method for the backward calculation of Liechtenstein's GDP requires annual (sectoral) employment figures, which are estimated along with this project. This contribution therefore also removes severe data gaps in this special context. These new employment data series also enhance the base for economic investigations in analytical terms.[28] Additionally, as the newly computed GDP-values make a long and consistent time series for Liechtenstein's GDP available for the first time, a prediction model (that serves as benchmark-model to the official GDP-forecast by the KOFL) will also be proposed in chapter 1.4. (in its last section).

[28] These newly estimated sectoral and total employment figures have already been applied in BRUNHART, KELLERMANN AND SCHLAG [2012], where they played a role in the analysis of Liechtenstein's economic fluctuations and growth (in terms of potential output) over the past decades.

1.4.1. Backward-Calculation of Liechtenstein's GDP

Apart from the fact that national accounting is a very demanding, delicate and time-consuming task, even for a very small country such as Liechtenstein, additional problems arise when it comes to the backward calculation of aggregates: On the one hand, many important series have not been compiled before the establishment of national accounting. In the context of Liechtenstein this problem is even worse, since the base of economic data is very scarce, especially before 1998, which was the first year of national accounts. Hence, serious problems for many sub-accounts appear when one tries to replicate the results for 1998 until 2009 or especially to carry out calculations for the time before the introduction of Liechtenstein's official national accounting system (Volkswirtschaftliche Gesamtrechnung Liechtenstein, VGR FL) in 1998: Either relevant data had not been collected before the national accounts were introduced in 1998, or they exist but are not available anymore or they are simply not accessible for the public.

It must be stated at this point that no method can be adopted here from examples of other countries. First of all, for every country, the method needs to be developed as a function of the existing series. It is not very pragmatic to simply transfer a method if the pool of available indicator series is incomparable. Additionally, the methods quoted in the scientific literature usually cover time-periods that go further back in history. Also, the already existing number of GDP-observations is too small for regression-based retropolation.

The chosen approach for the computation of Liechtenstein's gross domestic product figures for the years from 1972 until 1997 relies on the identity of the so-called "generation of income account":

	Compensation of Employees
plus	Gross Operating Surplus
plus	Taxes on Production and Imports
minus	Subsidies
=	Gross Domestic Product (GDP)

TABLE 24: Generation of income account

Even though the approach seems short, clear and elegant at first sight, it takes a very deliberate and time-consuming proceeding. In almost every sub-account and sub-component a lot of improvisation is necessary, heuristic talent needed and sometimes even an iterative line of action required. These pitfalls can originate from the relevant series themselves: They might exhibit data gaps or massive outliers or they might not be available for all the respective years. Sometimes a proxy is needed, because the data series does not exist or it exists but was not made accessible to the author (which unfortunately was the case on several occasions). Or it was a-priori unclear what strategy was optimal, because there was no reference procedure to rely on.[29] One example is the aggregated gross operating surplus by the companies. The adequate calculation of this component was crucial, since the gross operating surplus has an important share in GDP and exhibits a very high volatility. This component in turn is fundamental for the determination of the business cycle of the whole economy, measured for example by GDP-growth. There is no method for the direct computation of the gross operating surplus. Also, in the official national account it is determined in an indirect way as it is a residual to compromise, as a balancing item, the two sides of the compilation of the gross domestic product. But fortunately, the just mentioned pitfalls could be circumvented, as will be shown and explained later on in accurate detail.

Along with this project, also sectoral and total employment figures for Liechtenstein have been estimated, since these statistics do not exist for particular years, especially during the 1970s. The employment figures are an important element in the

[29] Even the official national accounts are only approximations to the true but unknown aggregates and sub-aggregates. This also holds for the special case of Liechtenstein.

estimation approach for the gross operating surplus. The detailed estimation process can be found in the appendix (1.A.3.).

1.4.1.1. Compensation of Employees

Generally speaking, the compensation of employees consists of all incomes that are earned by domestic employees. Payments of the employers for the employees' social insurance are also included.

In contrast to the following components (the subsidies and the taxes on production and imports), it is not possible to calculate the component compensation of employees in the same way as it is done in the official national accounts. The sum of all incomes received in Liechtenstein is officially released by the public pension insurance (Alters- und Hinterlassenenversicherung, AHV). The AHV collects and publishes the sum of all employees' aggregated incomes.[30] These annual aggregated total incomes serve as a valuable proxy to obtain a good estimate for the compensation of employees which is matchable with the official national accounts.

In an additional step, the payments of the employers for the employees' social insurance have to be added to the incomes of employees. These contributions by the employers to the employees' social security concern the following types of social incurances: Pension, widow(er) and orphan insurance (AHV), invalidity insurance (Invalidenversicherung, IV), family benefits (Familienausgleichskasse, FAK), unemployment insurance (Arbeitslosenversicherung, ALV), obligatory health insurance (Obligatorische Krankenversicherung, OKV) and mandatory occupational accident insurance (Berufsunfallversicherung, BUV) und contributions to the

[30] Employees have to pay 3.8% of their wages to the AHV. That is why the AHV gathers, knows and publishes the total of all wages/incomes. Also the employers have to contribute to the AHV with 3.8% of the employee's salary. This is one type of employers' contribution to the employees' social security. These contributions have to be added in a next step to the "ordinary" compensation (salaries) of the employees, since it is also a special form of compensation.

companies' pension funds by public and private employers. While the necessary data of the AHV, IV, FAK, ALV and OKV can be easily obtained in their public annual reports, the employers' payments to BUV are not published explicitly (at least not for some of the relevant years) and must be obtained indirectly by approximative calculations. Also, for the companies' pension funds, approximative calculations have to be applied.

Employers and employees are obligated to pay the equal share of the employee's obligatory health insurance. Therefore, the employers' payments can be deduced by taking half of the total amount of paid contributions. The total amount is found in the obligatory health insurance statistics and the Statistical Yearbooks issued by the national Office of Statistics.

The employers have to pay a share to the occupational accident insurance of the employees. Official figures for the mandatory accident insurance, published by the Office of Statistics, are available for the years 1975-1985 and from 1996 to the present. The problem is that there exist only consolidated figures for the occupational (Berufsunfallversicherung, BUV) and the non-occupational accident insurance (Nicht-Berufsunfallversicherung, NBUV) altogether. Values for the missing years can be well calculated by using indicator ratios: The percentage change of BUV and BUV+NBUV over time is almost the same between the two amounts. As the sum BUV+NBUV is known for the whole time period, the data gaps for BUV can be filled using the indicator ratio. Unfortunately, official figures for the payments of the companies to the pension funds of their staff (published in the Statistical Yearbooks by the national Office of Statistics) do not exist for each of the years within the regarded time span. Therefore, missing data must be approximated using interpolations. As the pension payments are proportional to the salaries, it makes more sense to use the percentage ratio (pension funds payments relative to total salaries) rather than just interpolating the absolute amount of pension fund payments.

		1972	1973	1974	1975	1976	1977	1978	1979	1980
Gross Wages and Salaries		230.5	270.9	318.6	322.0	344.9	395.2	406.9	451.7	503.0
Employers' Social Contributions	Pension/Widow(er)/Orphan Insurance; Invalidity Insurance; Family Benefits	13.0	19.3	22.7	22.9	23.8	27.7	28.5	31.6	35.2
	Unemployment Insurance	*1.4*	*1.4*	*1.4*	*1.4*	1.4	1.5	1.6	1.7	2.0
	Obligatory Health Insurance	*1.4*	*1.6*	*1.8*	2	2.2	4.1	4.3	4.9	5.1
	Occupational Accident Insurance	4.0	4.4	5.4	5.4	5.1	5.2	5.4	6.8	6.2
	Companies' Pension Funds	*7.3*	*8.6*	9.2	*10.3*	*11.2*	*12.9*	*13.5*	13.2	*17.8*
Compensation of Employees		**258.4**	**307.0**	**359.8**	**365.5**	**390.2**	**448.5**	**462.2**	**511.9**	**571.3**
		1981	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Gross Wages and Salaries		517.7	579.1	593.5	643.7	686.5	751.9	780.6	881.6	947.0
Employers' Social Contributions	Pension/Widow(er)/Orphan Insurance; Invalidity Insurance; Family Benefits	36.3	40.6	41.6	45.1	48.1	52.7	54.7	61.8	66.3
	Unemployment Insurance	0.9	0.9	1.1	1.2	1.3	1.4	1.4	1.6	1.6
	Obligatory Health Insurance	5.3	5.9	6.8	7.9	9.6	10.0	10.4	11.3	12.1
	Occupational Accident Insurance	3.2	3.2	3.3	3.8	3.9	4.1	4.2	4.4	4.1
	Companies' Pension Funds	*19.2*	*22.5*	*24.1*	*27.3*	*30.3*	*34.4*	*37.2*	*43.5*	*48.4*
Compensation of Employees		**585.1**	**655.6**	**674.2**	**733.2**	**784.2**	**860.2**	**893.5**	**1'009.8**	**1'085.5**
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	
Gross Wages and Salaries		1'029.0	1'103.5	1'151.0	1'197.9	1'246.2	1'347.1	1'338.9	1'406.9	
Employers' Social Contributions	Pension/Widow(er)/Orphan Insurance; Invalidity Insurance; Family Benefits	72.1	77.3	80.6	83.9	87.3	92.0	92.8	97.5	
	Unemployment Insurance	*2.0*	2.2	2.1	2.6	3.0	3.1	3.1	3.1	
	Obligatory Health Insurance	21.5	13.7	14.9	16.1	17.4	17.8	16.9	19.2	
	Occupational Accident Insurance	4.4	4.6	6.0	6.1	6.4	8.4	8.7	8.7	
	Companies' Pension Funds	*54.4*	*60.2*	*64.9*	*69.6*	*74.6*	*75.2*	76.7	81.1	
Compensation of Employees		**1'180.8**	**1'268.1**	**1'326.5**	**1'383.1**	**1'442.3**	**1'551.4**	**1'545.1**	**1'625.1**	

TABLE 25: Computed compensation of employees (in Mio. CHF)

The ratio of the years 1970 (3.23%), 1974 (3.15%), 1979 (3.36%), 1996 (6.63%) and from 1997 to the present are known. The values between these years are linearly interpolated and then used for the approximation of the total annual payment of the companies to the workers' pension fund. Again, as in chapter 1.3., figures in *italics* in TABLE 25 (which displays the compensation of employees) and in the following tables rely on approximative calculations or estimations by the author of this dissertation.

1.4.1.2. Gross Operating Surplus

The accurate calculation of this component (gross operating surplus) is very important as it features a high amount of volatility which contributes to the whole fluctuation in the national gross domestic product. The other three components (compensation of employees, subsidies, and taxes on production and imports) feature a lower volatility. The gross operating surplus is therefore the key to identifying and analysing the business cycle of Liechtenstein's economy.

Unfortunately, it is not possible to calculate the gross operating surplus in a direct mode: First, the needed data from the national tax administration are either not accessible for the public or not available back until 1972. Secondly, in the official national accounts, this component is not directly calculated, but obtained as remaining residual from different sides of the accounting system (see TABLE 1). The theoretical definition of the gross operating surplus consists of the operating profits of the firms within the economy. Since the data base is very scarce in Liechtenstein or simply not accessible to the public, the author of this paper has contacted the biggest companies (about 30 corporations) in Liechtenstein in order to obtain a good indicator for the development of the gross operating surplus in the whole economy. Those companies willing to provide data granted access to balance sheets and profit and loss statements for the years 1972 until 2008,[31] in most cases under the condition of complete discretion.[32]

While the considered financial institutions exhibit data back until their years of foundation, the inspected industrial companies usually started an accounting which is sufficient for the calculation of the gross operating surplus by the first half of the

[31] When the compilation process took place, the most recent year with detailed national accounting figures was 2008. In December 2011, official figures for the year 2009 were published by the Office of Statistics. Though, the time period 1998-2008 suffices for evaluation matters.

[32] For this reason, all the used data were deleted after the calculations had been executed and revised. Also, the results are only displayed here in a degree of disaggregation that does not unveil any information about single companies.

1970s. The author has tried to obtain (from each company and each year, beginning with 1972) a measure which comes close to the definition of the national accounts. The targeted figure was the EBITDA (earnings before interest, taxes, depreciation, and amortisation). Thus, for each year and each company this figure has been calculated, in many cases through a deliberate process of gathering and processing all the relevant information within the companies accounting books. Though, the standards of companies' accounting differ among the companies and have also been changing over time. Hence, the needed target figures have been calculated in the most comparable and coherent manner. Sometimes, if some desired elements of the earnings statement had not been disposable, the EBITDA was estimated using for example indicator ratios or other kinds of approximations.

Also, to build a good indicator and to weigh the various corporations within their sector, the number of employed people has also been collected for each year. For some companies, some years were missing and heuristic interpolation was needed, considering external information such as the judgement of the companies' contact person, personal costs of the companies as indicator or additional facts from the annual reports. These employment figures of each company were used to weigh their EBITDA and to multiply them to the surplus of the whole sector. The hereby captured shares of employment by the included companies as percentage of the whole sector are around 35% in the industry sector and around 38% in the financial services sector. In order to be able to do so, national employment figures from 1970 on have been estimated and differentiated after the four sectors "industry and manufacturing", "financial services" (without financial intermediation services indirectly measured), "other services" and "agriculture and households", since official figures in such a detailed level only exist for around twenty years back from now (the procedure and the detailed results are outlined in the appendix 1.A.3.).

The two other sectors (besides the sectors "industry/production" "and financial services") "other services" and "agriculture/private households" have to be

statistically retropolated, since it is impossible to gather data about the gross operating surplus of corporations which could be seen as being representative for the whole sector. Fortunately, these two sectors are considerably less volatile and feature a more continuous growth than the two sectors "industry/manufacturing" and "financial services". Thus, their evolution over time can be well approximated by deterministic growth models. Also, they are less important for the business cycle of the GDP in Liechtenstein compared to the other two sectors.

The annual gross operating surplus of the sector "other services" is estimated using a linear trend of the gross operating surplus per employed person within this sector over time (with the years 1998 to 2009 as reference years for the regression). The exponential shape of the retropolated regression line evolves because the observed number of employed persons has also strongly increased. In contrast, the aggregated operating surplus of agriculture/households is regressed on an exponential function of the total surplus and not on a per-capita base. The regression equations of the sector "agriculture/private households" is:[33]

$$\textit{gross operating surplus (agriculture/households)} = 57.021 \cdot e^{0.0494 \cdot t}$$

For the sector "other services", the regression results are:

$$\textit{gross operating surplus per employee (other services)} = 426.63 \cdot t + 20'821$$

The retropolated figures from these two regressions are displayed in FIGURE 14, which also charts the gross operating surplus of industry/production and financial services (the dotted lines are computed values, the figures from 1998-2009 are results by the official national accounts).

[33] The time index t is set to 1 in the year 1972.

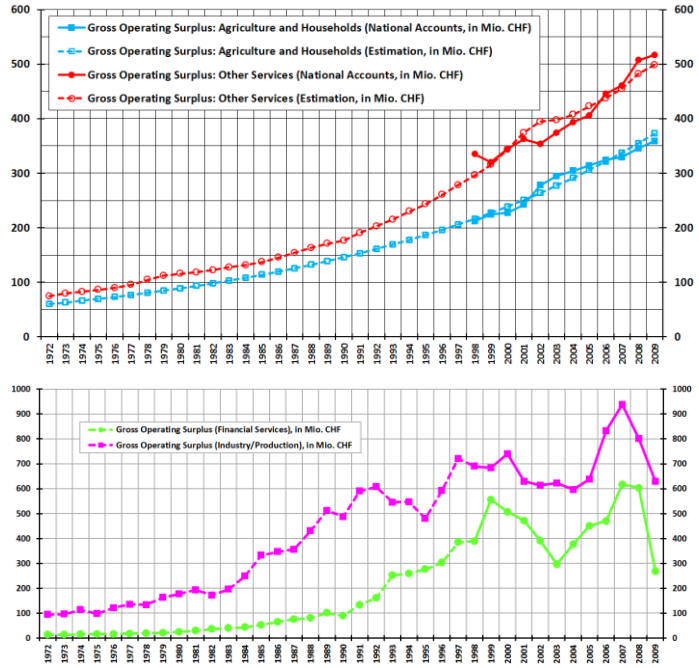

FIGURE 14: Gross operating surpluses of the four regarded sectors of the economy

TABLE 26 shows the total of the gross operating surplus compiled as the sum of sectoral gross operating surpluses of the four sectors "industry/manufacturing", "financial services", "other services" and "agriculture/households".

Gross Operating Surplus	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**
	241.6	250.8	276.3	267.9	299.6	324.7	336.9	378.3	405.5
	1981	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
	432.8	426.9	464.7	530.1	634.2	673.0	709.2	802.9	918.8
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	
	894.6	1'062.7	1'126.4	1'171.9	1'204.5	1'176.6	1'340.6	1'576.6	

TABLE 26: Computed total gross operating surplus as total of the four sectors (in Mio. CHF)

1.4.1.3. Taxes on Production and Imports

The sub-account "taxes on production and imports" can be calculated in the manner of the official national accounts of Liechtenstein. The relevant data sources are the national income statement, the annual governmental report, the national tax administration and also Swiss authorities such as the Swiss Federal Customs Administration, the Swiss Federal Tax Administration and the Swiss Alcohol Board.

Since Liechtenstein and Switzerland share a monetary and economic union (custom treaty and Swiss Franc as common currency), some of the different taxes on production and imports are raised and processed by Swiss authorities. Thus, the actual paid tariffs and taxes by inhabitants and companies in Liechtenstein must be approximated on the base of economic reasoning. In OEHRY [2000, p.139 and pp.257-267], the detailed approach (also adopted here) within the national accounts is outlined. Liechtenstein's monetary shares of these taxes and tariffs are calculated by different measures such as the number of inhabitants and/or the national income. Either only the ratio of both countries' national incomes is used as the ratio for the distribution of the share between the nations. Or the average of the ratios of inhabitants and national income is applied. The data provided by Liechtenstein's tax administration can be misleading in this context, since all the shares for the actual division of money between the countries are calculated using data from earlier years. Liechtenstein's tax administration publishes annual figures for most of these tariffs and taxes. But these are the actual amounts paid from Switzerland to Liechtenstein in that particular year (and not a measure of the actual economic share). So for example, Liechtenstein's earnings for the value added taxes in the year 1996 are not the real value added taxes paid in the year 1996, but result from Switzerland's payment to Liechtenstein from the common pool. This payment depends on the calculated share in 1996 which is a function of national income and population from weighted years before 1996.

In the application here, in a first step, the compilation of the population and of the national income of both countries is necessary in order to be able to calculate the figures for each type of tax or tariff, which is divided between the two countries and needed for this part of the national accounts. While population figures are provided by the official statistics of both nations it is more difficult to obtain national income figures. Even though Swiss national income is available for the whole period, the rules of national accounting and calculation have changed several times. In order to obtain a coherent series of the Swiss national income, a chained series which is

comparable and coherent through the whole time span has been generated along with this dissertation.[34] In Liechtenstein only official figures of national income from 1998 onwards exist. For this reason, as outlined in the previous sub-chapter dealing with the national income's backward calculation, annual figures from 1997 back to 1954 have been established: First, the national income for the years 1993-1997 was computed (on national accounting grounds). Then, the years 1992-1971, 1965-1964, 1962-1961 and 1959-1954 were backwardly estimated (using indicators and regressions). There already existed some national income estimations for the years 1960, 1963 and 1966-1970 (by SCHNETZLER [1966] and KRANZ [1973]), which were chained on econometric grounds with the estimations just mentioned.

TABLE 27 shows the considered data and their sources. In this table, the words in *italics* depict those taxes or tariffs, which are distributed between Switzerland and Liechtenstein.

[34] Basically, there have been three kinds of accounting regimes concerning the Swiss national income: the old Swiss national accounting (Schweizerische Nationale Buchhaltung) with annual figures from 1948 to 1995, the national accounting after the rules of ESA78 with annual figures from 1990 to 2001 and the national accounting relying on ESA95 with annual figures from 1990 to 2007. To obtain a coherent series from 1972 until 2008, which is needed for the calculation of the taxes on production and income, the ESA95 series serves as foundation. For the years before the growth rates of the old Swiss national accounting figures have been used here as an indicator for annual growth and applied to the ESVG95-series in order to generate backward estimates for the years before 1989. A similar procedure was also applied by Seco to generate an official historic time series for the Swiss GDP.

Taxes on Production and Imports	Authority/Source	Distribution Key
Value Added Tax (Mehrwertsteuer, Warenumsatzsteuer)	*Swiss Federal Tax Administration (Eidgenössische Zollverwaltung)*	*National Income*
Petroleum Tax (Mineralölsteuer)	*Swiss Federal Tax Administration (Eidgenössische Zollverwaltung)*	*National Income*
Tobacco Tax (Tabaksteuer)	*Swiss Federal Tax Administration (Eidgenössische Zollverwaltung)*	*National Income, Population*
Beer Tax (Biersteuer)	*Swiss Federal Tax Administration (Eidgenössische Zollverwaltung)*	*National Income, Population*
Vehicle Tax (Automobilsteuer)	*Swiss Federal Tax Administration (Eidgenössische Zollverwaltung)*	*National Income, Population*
Import Tariff (Einfuhrzoll)	*Swiss Federal Tax Administration (Eidgenössische Zollverwaltung)*	*National Income, Population*
Tobacco Tariff (Tabakzoll)	*Swiss Federal Tax Administration (Eidgenössische Zollverwaltung)*	*National Income, Population*
Agricultural Tariffs (Zolleinnahmen in der Landwirtschaft/Weinbau)	*Swiss Federal Tax Administration (Eidgenössische Zollverwaltung)*	*National Income, Population*
Tax on Speciality Brandy (Steuer auf Spezialitätenbranntwein)	*Swiss Alcohol Board (Eidgenössische Alkoholverwaltung)*	*National Income, Population*
Tax on Sales of Pomes Brandy (Selbstverkaufsabgabe auf Kernobstbranntwein)	*Swiss Alcohol Board (Eidgenössische Alkoholverwaltung)*	*National Income, Population*
Alcohol Monopoly Fee (Alkoholmonopolgebühren)	*Swiss Alcohol Board (Eidgenössische Alkoholverwaltung)*	*National Income, Population*
Taxes on Sales of Drinking Spirits and Brandy (Verkauf Trinksprit und Kernobstbranntwein)	*Swiss Alcohol Board (Eidgenössische Alkoholverwaltung)*	*National Income, Population*
Special Tax on Foreign Insurance Companies (Bes. Gesellschaftssteuer ausl. Versicherungen)	Liechtenstein Tax Administration (Liechtensteinische Steuerwaltung)	
Stamp Duties (Stempelabgaben)	Liechtenstein Tax Administration (Liechtensteinische Steuerwaltung)	
Property Gain Taxes (Grundstückgewinnsteuer)	Liechtenstein Tax Administration (Liechtensteinische Steuerwaltung)	
Taxes on Vehicles Used for Production (Motorfahrzeugssteuer, Fahrzeuge Produktion)	Liechtenstein Tax Administration (Liechtensteinische Steuerwaltung)	

TABLE 27: Components of taxes on production and imports

Regarding the special tax on foreign insurance companies and the different kinds of stamp duties, some weights are applied in Liechtenstein's national accounts.[35] For the different kinds of stamp duties the individually applied share weights are in line with the rules of thumb of the practice of Liechtenstein's official national accounts.

Unfortunately, some official data sources, which are used in the official national accounts, relating to some of the commissions on production are not publicly accessible. Yet, their quantitative importance is rather small. They are therefore approximated, also taking into account the evolution of other taxes on production over time in Switzerland.

[35] The applied weighting factors are taken from the national accounts: Special tax on foreign insurance companies (1/3) and the different kinds of stamp duties. These stamp duties are: "Effektenumsatzabgabe" (0.2), "Emissionsabgabe" (0.9), "Abgaben auf Versicherungsprämien" (1/3) and "Gründungs- und Wertstempelgebühr" (0.25).

Taxes on Productions and Imports	1972	1973	1974	1975	1976	1977	1978	1979	1980
	33.9	37.5	38.9	40.3	46.4	53.2	55.9	63.2	72.9
	1981	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
	75.2	84.9	86.0	100.4	112.5	125.8	130.1	131.4	165.5
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	
	156.5	157.8	161.7	162.3	164.7	191.5	193.4	207.7	

TABLE 28: Computed figures for taxes on production and imports (in Mio. CHF)

TABLE 28 includes the computed figures for the aggregate taxes on production and imports, which is a sub-component of the gross domestic product.

1.4.1.4. Subsidies

After adding the taxes on production and imports to the sum of gross operating surplus and the compensation of employees, the subsidies have to be subtracted to obtain the national gross domestic product as a total. Regarding the whole time span of the official GDP figures of Liechtenstein (1998-2009), the subsidies contribute between 1.3% and 2.1% to the total absolute sum. Thus, they are clearly the least important component of the generation of income account which yields the GDP as a total.

Almost all of the relevant data concerning the subsidies are publicly accessible and can be obtained from official statistics such as the national income statement.[36] This enables the subsidies to be calculated for the whole time-span (1972-2008) according to the rules of the official national accounts of Liechtenstein. The years 1998-2008 can then be used to compare the estimated values with the official values in order to determine the accuracy (this will be investigated in further detail in section 1.4.1.6.). The considered subsidies consist of the subsidies of products and other subsidies on production (for further details see OEHRY [2000, pp.144-147]). In the following, the components of both groups are listed, along with the German

[36] The municipalities‘ subsidies are also included in the total subsidies of the official national accounts. Nonetheless, they are neglected here due to the highly time-consuming compilation process compared to their small quantitative relevance. Additionally, the income statements of some of the municipalities are not accessible back to 1972 anymore.

terms used in the national income statement of the annual governmental report (in brackets).

The *subsidies on products* included into the computations are: Subsidies for milk producers (Beitrag für die Milchwirtschaft), subsidies for sheep wool (Subventionen für Schafwolle), subsidies for cattle insurance (Beitrag an die liechtensteinische Viehversicherung), subsidies for health insurance (Krankenkassensubventionen), subsidies for accident insurance (Subventionen für Unfallversicherungen), deficit guarantee for the national publisher of teaching aids (Defizitabdeckung des amtlichen Lehrmittelverlags) and subsidies of public transportation (Beitrag an die Liechtensteinische Bus Anstalt).

The *other subsidies on production* that are included in the calculation process are: Subsidies for summering expenses (Alpungskostenbeitrag), subsidies for the maintenance of hillside locations (Beitrag zur Förderung der Berglandschaft), subsidies for the improvement of agricultural income (Beitrag zur Verbesserung des landwirtschaftlichen Einkommens), subsidies for the compensation of ecological and animal friendly services (Beitrag zur Abgeltung ökologischer und tiergerechter Leistungen), subsidies for the inspection of milk yield (Beitrag für die Milchleistungskontrolle), subsidies for hail insurance (Beitrag an die Hagelversicherung), interest subsidies for the promotion of agricultural buildings (Zinszuschüsse zur Förderung des landwirtschaftlichen Bauwesens)[37], subsidies for public producers (staatliche Beiträge an öffentliche Produzenten), subsidies for adult education (staatliche Beiträge an die Erwachsenenbildung), subsidies for national foundation for care of elderly and patients (staatliche Beiträge Stiftung liechtensteinische Alters- und Krankenhilfe), subsidies for the national post (staatliche Beiträge an die Liechtensteinische Post), subsidies for the national hospital (staatliche Beiträge an das Landesspital), state share of foresters' wages (Landesanteil an den Försterlöhnen der Gemeinden), state share of day nursery

[37] Only 50% of the amount of the interest subsidies is considered in the summation of the total subsidies.

expenses (Landesbeiträge an Kinderhorte der Gemeinden), subsidies for broadcasting (Beiträge an den Rundfunk).

Subsidies	1972	1973	1974	1975	1976	1977	1978	1979	1980
	4.2	5.3	6.5	6.9	7.9	9.3	10.3	10.7	12.1
	1981	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
	13.2	13.7	14.3	16.3	17.2	18.6	20.4	20.9	23.2
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	
	26.6	26.7	29.6	30.9	34.5	37.9	41.7	45.6	

TABLE 29: Computed subsidies (in Mio. CHF)

In TABLE 29, the calculated subsidies for the whole time span from 1972 until 1997 are listed and show a rather smooth and continuous growth over the regarded time-span.

1.4.1.5. Addition of the Four Components to GDP

After having obtained annual figures for the four sub-accounts of the generation of income account that determinate the annual GDP, all the four sub-accounts can be totalled. These calculations are shown in TABLE 30.

	1972	1973	1974	1975	1976	1977	1978	1979	1980
Compensation of Employees	258.4	307.0	359.8	365.5	390.2	448.5	462.2	511.9	571.3
Gross Operating Surplus	241.6	250.8	276.3	267.9	299.6	324.7	336.9	378.3	405.5
Taxes on Production and Imports	33.9	37.5	38.9	40.3	46.4	53.2	55.9	63.2	72.9
(minus) Subsidies	4.2	5.3	6.5	6.9	7.9	9.3	10.3	10.7	12.1
Gross Domestic Product	529.7	590.0	668.5	666.8	728.4	817.1	844.7	942.7	1'037.6
	1981	1982	1983	1984	1985	1986	1987	1988	1989
Compensation of Employees	585.1	655.6	674.2	733.2	784.2	860.2	893.5	1'009.8	1'085.5
Gross Operating Surplus	432.8	426.9	464.7	530.1	634.2	673.0	709.2	802.9	918.8
Taxes on Production and Imports	75.2	84.9	86.0	100.4	112.5	125.8	130.1	131.4	165.5
(minus) Subsidies	13.2	13.7	14.3	16.3	17.2	18.6	20.4	20.9	23.2
Gross Domestic Product	1'079.9	1'153.9	1'210.7	1'347.5	1'513.6	1'640.4	1'712.4	1'923.2	2'146.6
	1990	1991	1992	1993	1994	1995	1996	1997	
Compensation of Employees	1'180.8	1'268.1	1'326.5	1'383.1	1'442.3	1'551.4	1'545.1	1'625.1	
Gross Operating Surplus	894.6	1'062.7	1'126.4	1'171.9	1'204.5	1'176.6	1'340.6	1'576.6	
Taxes on Production and Imports	156.5	157.8	161.7	162.3	164.7	191.5	193.4	207.7	
(minus) Subsidies	26.6	26.7	29.6	30.9	34.5	37.9	41.7	45.6	
Gross Domestic Product	2'205.4	2'461.9	2'585.0	2'686.4	2'776.9	2'881.6	3'037.5	3'363.8	

TABLE 30: Addition of computed sub-accounts to GDP

In FIGURE 15 the complete chained GDP-series is visible, in nominal and real terms. The official figures start by the year 1998, all the years before that year originate from the estimation just outlined in the prior sub-chapters. The years 2010 until 2012 are nowcasts and one forecast by KOFL, published in SCHLAG [2012, p.39].

The real GDP-values were deflated by using the Swiss GDP-deflator. The usage of Swiss deflators for Liechtenstein's economy is the applied practice by KOFL and also proposed by OEHRY [2000, p.345] and the national statistical office. It is reasonable also from a logical point of view, since Liechtenstein shares a monetary and economic union and a customs treaty with Switzerland.

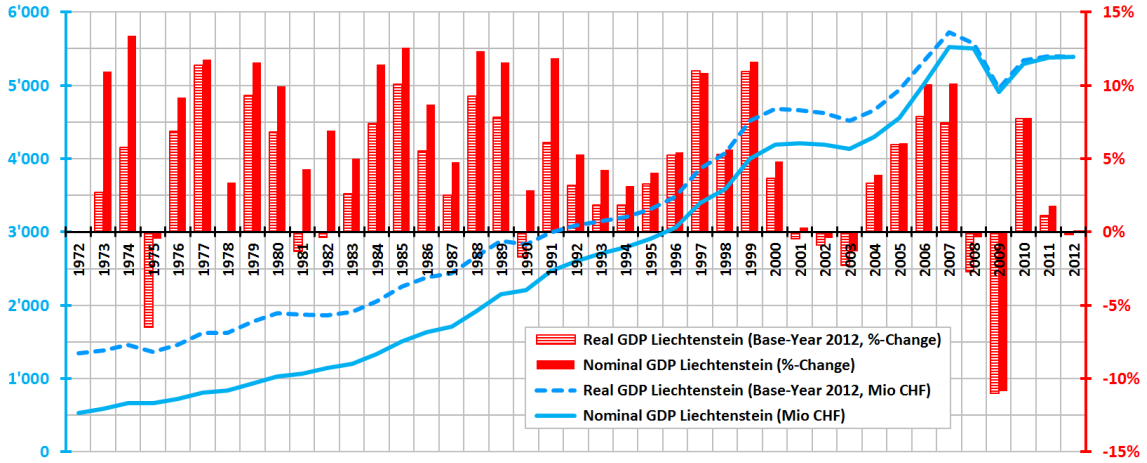

FIGURE 15: Computed (real and nominal) GDP-figures chained with the official GDP

For a deeper analysis of Liechtenstein's past long-term growth path, see BRUNHART, KELLERMANN AND SCHLAG [2012] who apply a preliminary version of the GDP-series that was estimated here. Inspecting Liechtenstein's business cycle, it can be seen that major economic fluctuations generally have a strong impact on Liechtenstein's economy: the first oil-price shock and the restrictive monetary policy of the Swiss National Bank in the first half of the 1970s. Then there are recessive developments in the late 1970s and the early 1980s detectable (Iranian Revolution and second oil-shock). Other downturns in economic growth can be traced in 1987 ("Black Monday"-crash on international stock markets) and first half of the 1990s (war in Iraq, „third oil-price shock", appreciation of the Swiss Franc). The high economic growth during the last years of the 90s was temporarily diminished by the Asia-crisis that affected important exporting companies and also financial institutes in Liechtenstein. Similarly striking are the two world recessions of the new millennium, especially the heavy downturn in 2008 and 2009 when the international financial crisis was accompanied with the Liechtenstein Tax Affair, which led to high insecurity and a transformation process in Liechtenstein's financial sector.[38]

[38] The different impacts of the financial crisis and the tax affair (a whistle blower sold data of thousands of tax evaders) on Liechtenstein's economy, especially on the stock values of Liechtenstein's quoted companies, have been investigated in BRUNHART [2012a]. As flash-estimates (OFFICE OF STATISTIC [2012]) and nowcasts of GDP (SCHLAG [2012]) show, Liechtenstein's economy featured a strong real recovery through the year 2010 while stagnating in 2011 (visible in FIGURE 23).

These mentioned economic events are also visible in the cyclical component (output gap) after removal of the positive growth trend over time by applying the filter of HODRICK AND PRESCOTT [1997] (HP-filter explained in the appendix 2.A.1.3.) on the real GDP-series. This cyclical component (as percentage deviation from the HP-trend) of the real GDP is visible in FIGURE 16 and FIGURE 21. On the latter mentioned figure the close movement to the cyclical component of Liechtenstein's national income can also be noted (but this will be dealt with later on, when the accuracy of the computed GDP-series is evaluated).

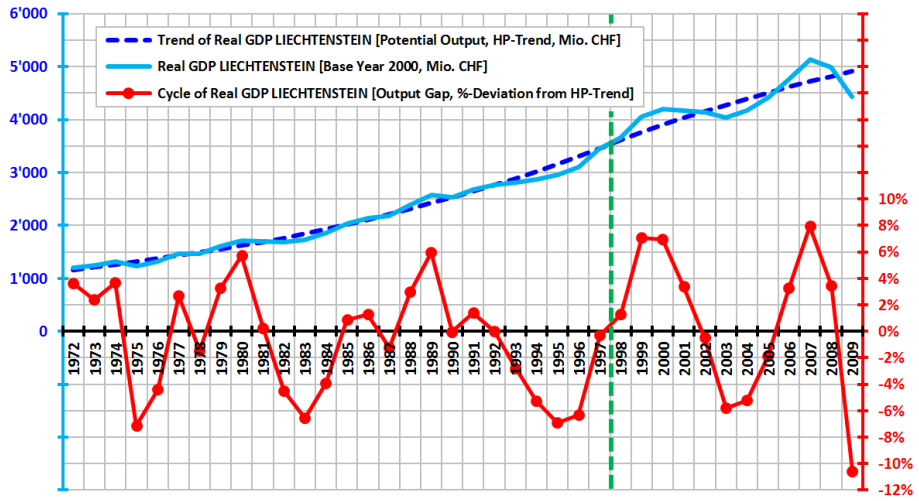

FIGURE 16: Potential output and output gap of Liechtenstein (derived by HP-filter on real GDP)

The four components adding to GDP and their evolution over time are illustrated in the following graph, the estimated figures from 1972 to 1997 and the official figures 1998 until 2008 have been linked.

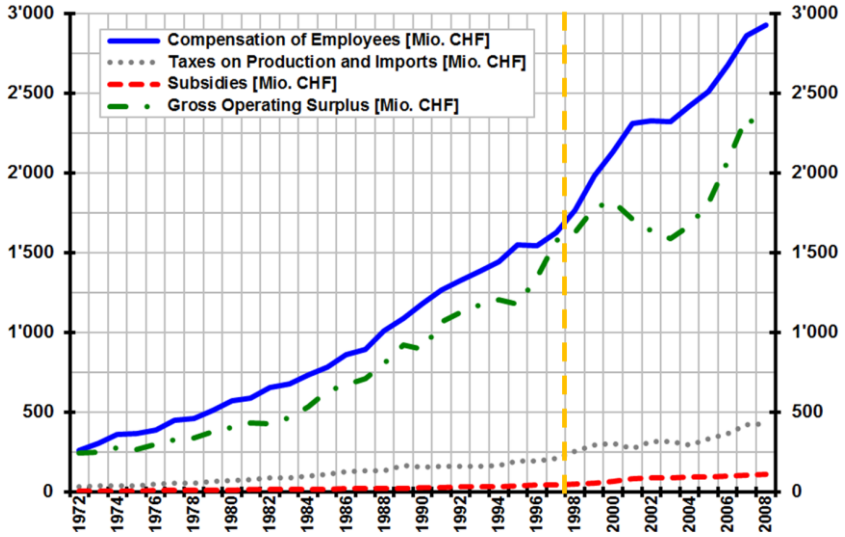

FIGURE 17: The four computed components of GDP over time

It is also interesting to identify the real percentage growth contribution of the four different sub-components of Liechtenstein's GDP in order to better understand the driving forces behind the business cycle. FIGURE 18 illustrates that especially the real growth contribution of the gross operating surplus is very volatile in the business cycle.

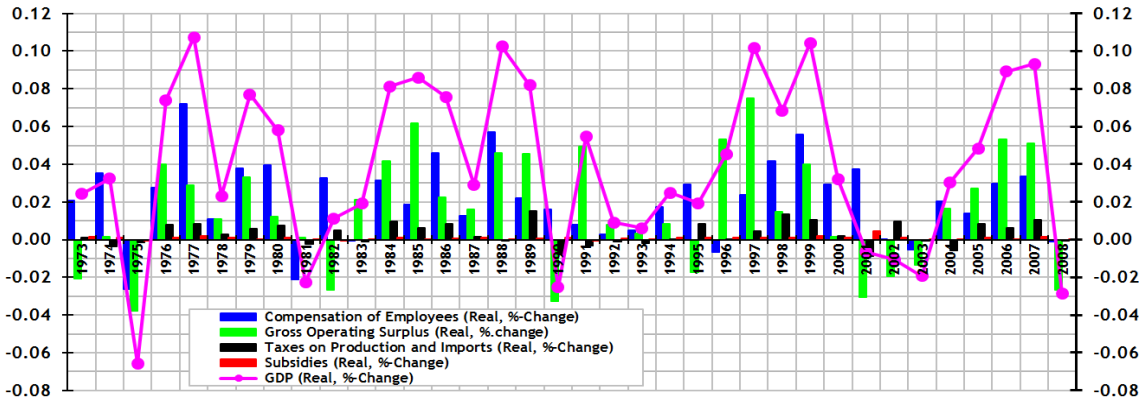

FIGURE 18: Real percentage growth contribution of four components of Liechtenstein's GDP

1.4.1.6. Evaluation of Computed GDP-Figures

It is now of central importance to evaluate the estimated GDP-series. A first step would be to compute and compare GDP-values of the years 1998 to 2008 with the official GDP-figures that have been published since 1998.[39]

	Mio. CHF	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
	Compensation of Employees	*1'747.4*	*2'005.7*	*2'064.3*	*2'199.1*	*2'285.3*	*2'244.9*	*2'312.3*	*2'438.8*	*2'597.6*	*2'755.8*	*2'932.0*
+	*Gross Operating Surplus*	*1'591.5*	*1'746.5*	*1'976.3*	*1'853.1*	*1'733.5*	*1'684*	*1'852.6*	*2'057.4*	*2'326.2*	*2'614.7*	*2'396.0*
+	*Taxes on Production/Imports*	*221.4*	*264.9*	*314.8*	*283.1*	*271.5*	*239.5*	*245.4*	*277.0*	*321.1*	*368.5*	*394.5*
-	*Subsidies*	*59.5*	*63.7*	*69.6*	*89.4*	*94.3*	*95.0*	*93.3*	*102.1*	*102.3*	*109.6*	*113.8*
=	*GDP (computed)*	*3'500.9*	*3'953.4*	*4'285.8*	*4'245.8*	*4'196.0*	*4'073.4*	*4'317.0*	*4'671.1*	*5'142.7*	*5'629.5*	*5'608.8*
	GDP (official)	3'595.1	4'001.9	4'194.8	4'205.2	4'190.3	4'135.3	4'295.6	4'556.4	5'015.4	5'523.5	5'503.7

TABLE 31: Computed and official GDP in the evaluation period (1998-2008)

TABLE 31 shows the results for the four components and their totals and contrasts them with the official GDP. The figures in *italics* denote computations of this chapter, while the values not in italics are official releases.

When the official and the computed (nominal) GDP-figures are plotted in FIGURE 19, a close fit can be visually observed. The average absolute deviation from the official number during these eleven years is 1.63%. This is low and clearly below the target by the national Office of Statistics, that calculates the official national accounts. The OFFICE OF STATISTICS [2012b, p.4] aspires an absolute deviation of less than 3% of their published flash-estimate of GDP compared to the finally revised figures.

[39] There exist national account figures also for 2009 (including GDP), but they are still provisional and will be revised in December 2012, when the official national account figures for 2010 are going to be published by the Office of Statistics. Also, the compiled data from the private companies only include the time span 1972-2008. Therefore, only the years 1998-2008 are taken into account for this evaluation.

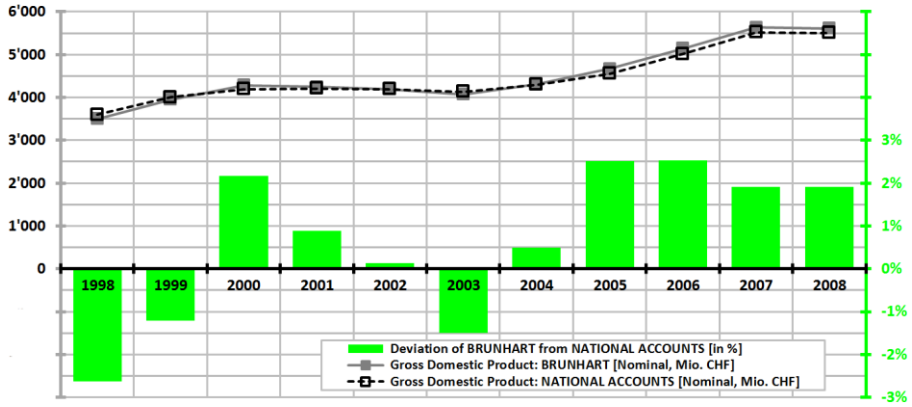

FIGURE 19: Evaluation of computed versus official GDP-figures

Also, a visual comparison of the nominal growth rates, which are very important to capture the business cycle pattern, unveils the good fit of the estimated series. In FIGURE 20, also the nominal GDP-estimates of the SGZZ, which were explained in the introduction of chapter 1.4., are displayed. As expected, those estimates are a bit lower than the estimations proposed here. The author has carried out a similar technique to the one of the SGZZ for the years 1990-2008 and transposed the sectoral added value figures from Switzerland (which are publically available from 1990 on) to Liechtenstein and has found out (as a-priori expected) that this strategy underestimated the actual GDP by about 10%-25%. This indicates that the GDP values estimated here and those by the SGZZ correspond well with the impression of underestimation by the SGZZ-method.

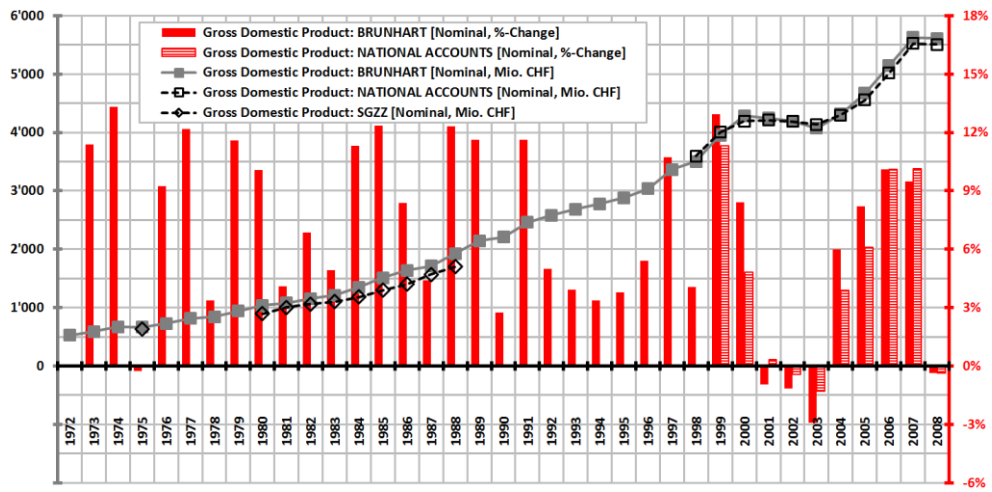

FIGURE 20: Different sources of nominal GDP of Liechtenstein

We also observe again the close fit of the computed values with GDP-figures of the official national accounts.

Additional insights can be drawn from calculating the correlation of the four components of GDP (and of their total) with the official numbers, as shown in TABLE 32. The correlation coefficients of the estimated and the actual GDP are very high: 0.9974 in levels and 0.9608 for their annual percentage growth (the correlation of the sub-components is either from 1998 until 2008 or 2009). Fortunately, the estimates of the gross operating surplus are very satisfying; this component has been the big challenge, since it contains a big share of GDP's volatility and because there was no benchmark method for its generation, neither in the literature nor in the official national accounts of Liechtenstein (as they are calculated as residual from other accounts).

CORRELATION	Compensation of Employees	Gross Operating Surplus	Taxes on Production and Imports	Subsidies	Aggregated Total (GDP)
Level	0.9915	0.9634	0.8911	0.9978	0.9974
%-Change	0.7676	0.8765	0.7768	0.9495	0.9608

TABLE 32: Correlation of estimated and actual figures (1998-2008)

The generated business cycle pattern seems very plausible, features no incomprehensible outliers and can be supported by economic interpretations (as has been done in the previous sub-chapter). Also, the four sub-components of the GDP show no severe outliers, without interpretation by economic reasoning. They are displayed in the FIGURE 17 and FIGURE 18.

If the two most important national accounting aggregates, which are now available in Liechtenstein over a longer time span, are compared then it is evident that both feature a very close cyclical pattern. Both time series, the aggregates real gross domestic product of Liechtenstein and real national income of Liechtenstein, were de-trended by the filter after HODRICK AND PRESCOTT [1997] in order to obtain a widely applied measure for the business cycle. The very high similarity of both

backwardly estimated aggregates is evident.[40] Hence, the computed GDP-figures from 1972 to 1997 are also plausible in this light.

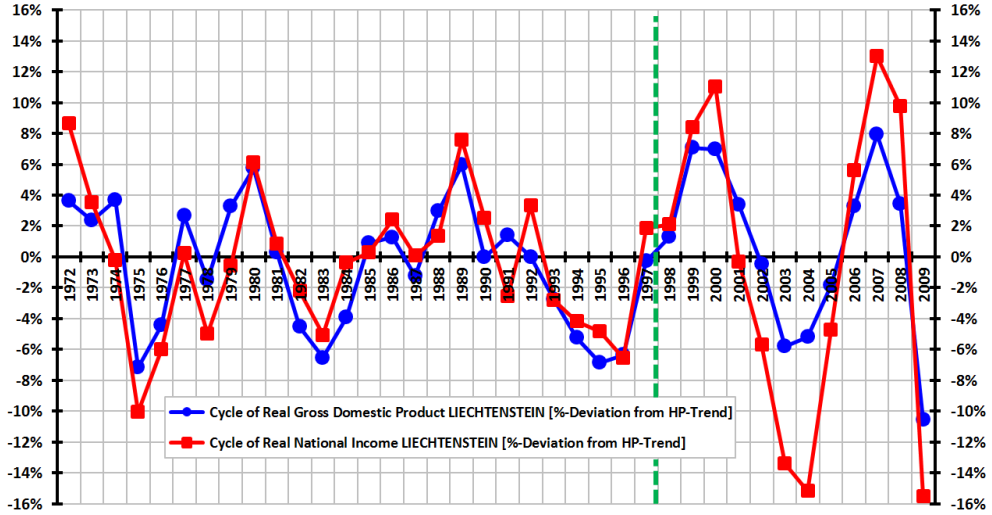

FIGURE 21: Cyclical components of Liechtenstein's real GDP and real national income

As observable from other countries (like Germany, Austria or Switzerland), the ratio of the compensation of employees to GDP has remained pretty stable over the past four decades. Thus, this fact can serve as a good evaluation test to find out whether this is also true for the Liechtenstein. If this also holds for the estimated values from 1972 to 1997, then an additional hint is obtained that the estimated GDP-figures are plausible. FIGURE 22 shows the ratios for the four quoted countries. The ratio has remained between 0.5 and 0.6, during both periods 1972-1997 (estimated values) and 1998-2009 (official figures).

[40] It is reasonable to compare both aggregates, which also imply approximated figures, for evaluations. Both series do not evolve from a similar (econometric or computational) model and are not solely a main function of only few data sources or just dependent on a very similar computation method.

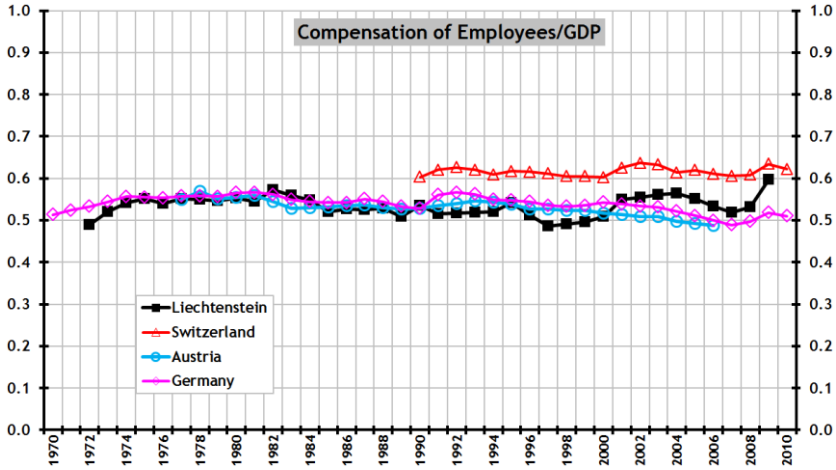

FIGURE 22: Ratio of Compensation of Employees relative to GDP

Also the ratio of the other very important component of GDP, the gross operating surplus, has been quite stable within a bandwidth of ranging from 0.35 to around 0.45 and shows no strong outliers.

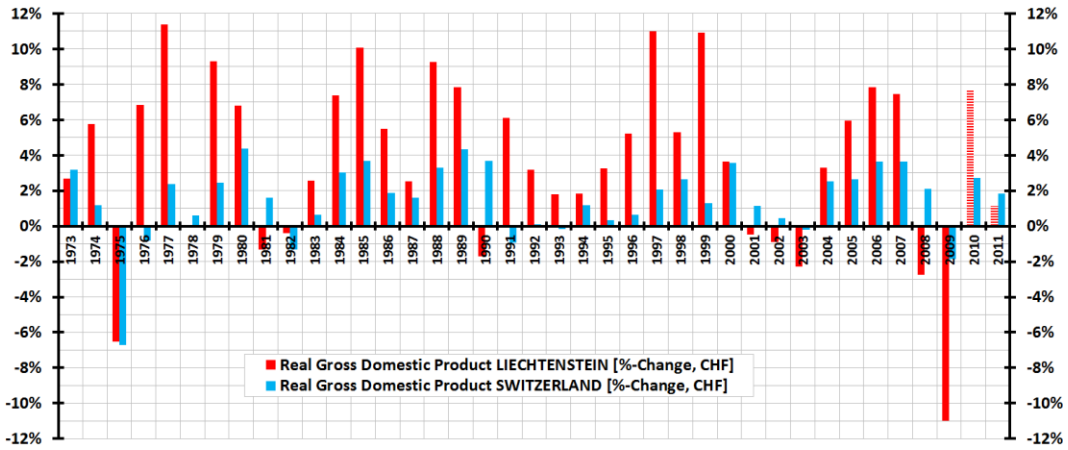

FIGURE 23: Real growth rates of Liechtenstein's and Switzerland's GDP

It is interesting to see that the business cycle of Liechtenstein has very similar characteristics to the Swiss economic short-term fluctuations. This impression applies to both the growth rates of real GDP (see FIGURE 23) and the output gap measured as the percentage deviation from the long-run trend of GDP, as shown in

FIGURE 24. Though, the amplitude is much higher, Liechtenstein is therefore characterized by a higher volatility.[41]

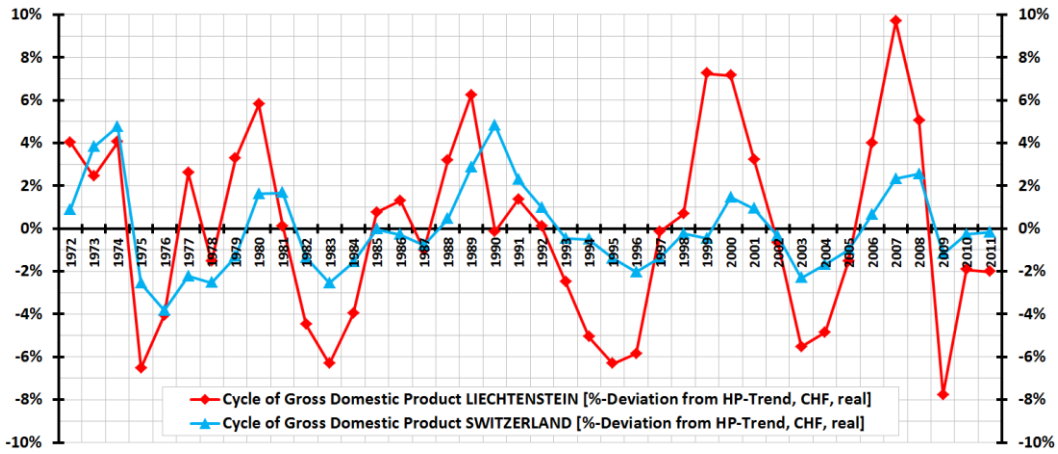

FIGURE 24: Cyclical amplitude of real GDP in Liechtenstein and Switzerland

After having applied a trend-filter to Liechtenstein's real GDP and inspected the cyclical behaviour (output gap), it is also worthwhile to concentrate on long-term growth (potential output) to compare the drift of the real GDP. A preliminary version of Liechtenstein's GDP is historic time-series is used that as well consists of the official values from 1998-2009 and computed values from 1972 until 1997 plus an econometric backward extension (1971-1954). In that preliminary version the same computation method was executed via the same procedure as in the PhD-thesis here, but as already mentioned, the figures were not the finally revised ones from this thesis. This preliminary time series was already applied in the contribution of BRUNHART, KELLERMANN AND SCHLAG [2012]. However, the preliminary estimated GDP-figures for 1972-1997 show almost completely the same cyclical pattern as the final ones in this paper. The time series of Liechtenstein's GDP in the just quoted paper was in addition econometrically extended by the author for the years 1971-1954 (applying a multiple regression model with indicators). These

[41] Reasons could be the very high share of exports (due to the small size of the country): Exports are usually very volatile in the business cycle. Additionally, the smaller diversification across the production and provision of different goods and services compared to bigger countries may play an important role leading to higher volatility. As it has already been observed regarding national income also the gross domestic product featured no visible moderation of volatility over time.

figures are now used in order to have a maximum number of observations. FIGURE 25 shows the growth of Liechtenstein's potential output, this growth is also called trend drift (violet line in FIGURE 25, whereas the real percentage growth of the raw GDP is marked by the dashed blue line). The trend drift is measured by the percentage growth of the trend of real GDP derived by the method of HODRICK AND PRESCOTT [1997]. There are clearly observable three phases, the two main breaks being in the middle of the 70s and by the end of the 90s. Especially the interesting period for evaluation reasons (1972-1997) shows a very similar development to the growth of potential output in Switzerland (red line in FIGURE 25). This also supports the reasonability of the estimated GDP-values for Liechtenstein provided in this dissertation. Yet, by the end of the sample, the continuous convergence between Switzerland and Liechtenstein seems to be completed.

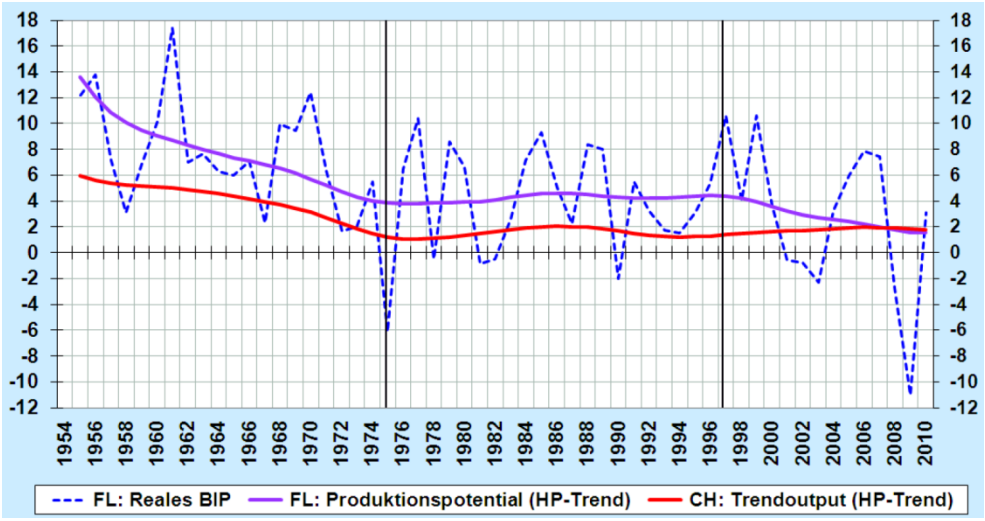

FIGURE 25: Growth of potential output (drift) of Liechtenstein and Switzerland (Source: BRUNHART, KELLERMANN AND SCHLAG [2012, p.10])

Also, KELLERMANN [2005] has detected two main structural breaks in Switzerland's economy for different important aggregates (such as GDP, GNI, production, employment) in the middle of the 70s and in 1997. This corresponds perfectly with the two observed structural breaks in the growth of potential output (drift), measured by the annual percentage growth of the trend (of Liechtenstein's real

GDP) that was determined applying the HP-filter on the newly estimated GDP-figures applying the method proposed in this dissertation (and already used in a preliminary version in BRUNHART, KELLERMANN AND SCHLAG [2012]). Hence, additionally to the findings considering the business cycle pattern the newly generated GDP-figures have again an intuitive economic interpretation that supports their accuracy, also in the context of structural breaks in the long-term growth path.

1.4.2. Benchmark-Model for GDP-Prediction

The Liechtenstein Economic Institute (Konjunkturforschungsstelle Liechtenstein, KOFL) publishes annual forecasts of Liechtenstein's GDP on behalf of the government. The reasons why the already difficult task of predicting the gross domestic product is an even more ambitious objective in the context of Liechtenstein are manifold:

- *Thin economic data base*: Compared to other countries the economic data base for the search for economic indicators is rather thin, even if annual frequency is considered. There exist only few important sources and most of the time series do not start before the 1990s. Many series also feature severe structural breaks or data gaps.

- *Nowcasting of GDP*: There is a long publication lag of Liechtenstein's GDP of almost 14 months (the reasons for this delay are outlined at the beginning of chapter 1.4.). Thus, before forecasting can be started, "nowcasting" has to be carried out first. The timing is usually as follows (chosen example is 2012): The Office of Statistics published the provisional flash-estimate of GDP for 2010 by the beginning of February 2012. Finally, by the end of February 2012, KOFL "nowcasted"[42] the GDP of 2010 and 2011 and forecasted the GDP of 2012. By December 2012, the Office of Statistics is going to release the full national accounts including preliminary final figures for the GDP of 2010.

- *Short reference series (GDP)*: Official figures for the nominal GDP only exist for the years from 1998 to 2009. Even if the nowcasts of 2010 and 2011 by

[42] In the applied nowcasting strategy estimations of the production output of the four sectors "industry/manufacturing", "financial services", "other services", and "agriculture/private households" are carried out. These approximations rely on the system of national accounts (see SCHLAG [2012, p. 22]).

KOFL are included, then only 14 observations of the reference series, which is supposed to be predicted, exist. This was one motivation for the backward-calculation of Liechtenstein's GDP for the years 1972-1997 that was outlined in the previous sub-chapters. Now there are 40 observations of GDP available.

- *Specific business cycle pattern*: Liechtenstein's economic growth shows strong fluctuations. Consequently, the business cycle features a very high volatility with sharp turning points and a remarkable amplitude (real growth rates of GDP range from -12% to +10% during the past four decades). This makes point forecasts very difficult. Additionally, it seems that Liechtenstein's business cycle exhibits (presumably) leading properties compared to the cycles of neighbouring countries, whereas lagging behaviour would make forecasting easier.

Now that a coherent and long GDP-series finally exists (for the years 1972-2011, computed in the previous section), an additional kind of prediction-model can be introduced, a non-structural approach that complements the existing approach by KOFL. This model takes advantage of the full available GDP-sample and not just 1998-2011, as has been done so far. To be considered are ordinary and comparably easy applicable univariate and multivariate time series models, such as different ARMA- (after BOX AND JENKINS [1979]), ARMAX- and VAR-models. The chosen specification represents a "cheap" benchmark-model to the official GDP-forecast by KOFL. The prediction process applied by KOFL is more of a structural nature and way more complex and also contains iterative-analytical judgment and heuristic proceeding besides econometric modelling of future influences on Liechtenstein's business cycle.

The series that shall be predicted within this empirical project is the nominal GDP of Liechtenstein. There are several reasons, why the nominal GDP is used instead of

the real GDP: In the course of the official national accounts only nominal values are published, since no official price indices exist for Liechtenstein. Also, all the considered indicator series are measured in nominal terms (Swiss Francs), too.

At first, attention should be paid to the dependent series being forecasted: The nominal GDP of Liechtenstein is plotted in FIGURE 26.[43] Several internationally identified recessions are observable, such as the first and the second oil crises, the low economic performance in the first half of the 90s and the two recent recessions. Also evident is the very high range of the nominal growth rates from more than plus 13% to minus 10%.

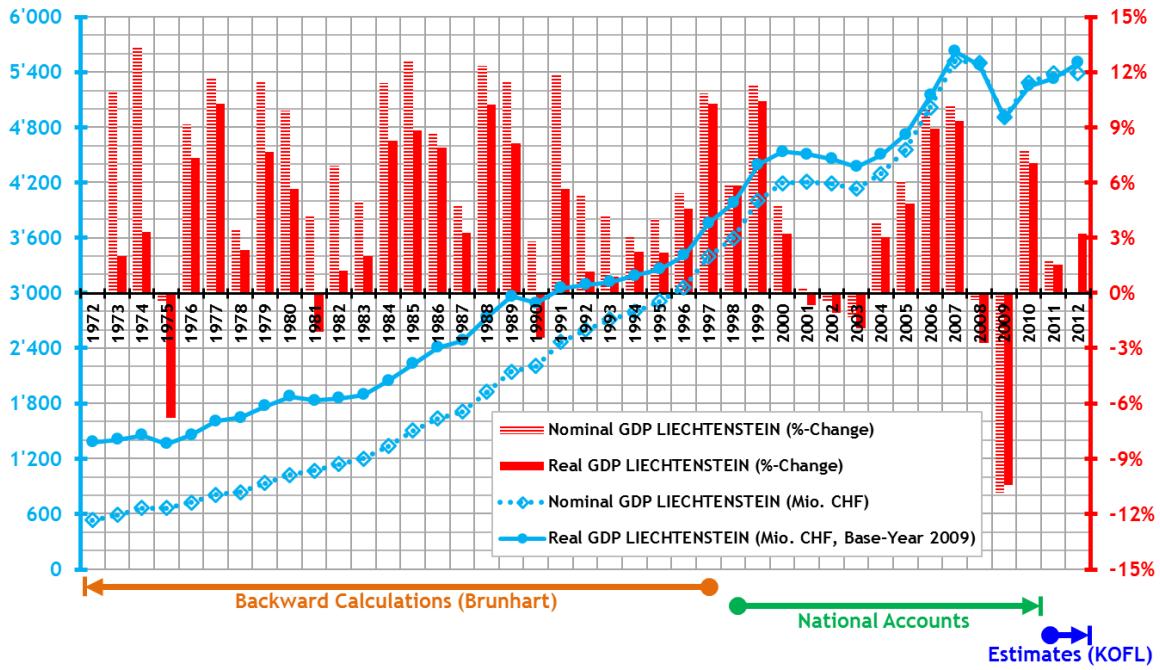

FIGURE 26: Liechtenstein's GDP [left hand scale] and growth rates [right hand scale]

[43] For the calculation of the real GDP the Swiss Index of Consumer Prices (Landesindex der Konsumentenpreise, LIK) has been used. This approach is supportable and usually applied since there exists a customs treaty between Switzerland and Liechtenstein since 1923 and because the Swiss Franc is used by both states as their official currency.

1.4.2.1. Descriptive and Analytical Data Inspection of Time-Series

The three chosen indicator series have been selected from about 30 series according to their correlation with Liechtenstein's GDP. An additional requirement apart from the correlation with GDP was that these series can be obtained with a short publication lag.

The series are taken from the annual Statistical Yearbook (OFFICE OF STATISTICS [2012a]), except for the Swiss GDP which is published by Swiss Statistics (http://www.bfs.admin.ch). The used indicator series are shown along with Liechtenstein's GDP in the following graph of FIGURE 27, the dotted lines at the end of the sample are projections. The exports are Liechtenstein's goods exports published by the Swiss Federal Customs Administration (Eidgenössische Zollverwaltung, EZV), exports to Switzerland are excluded. The wages include all labour income of employees and self-employed people that are subject to Liechtenstein's mandatory public pension insurance (Alters- und Hinterlassenen-versicherung, AHV).

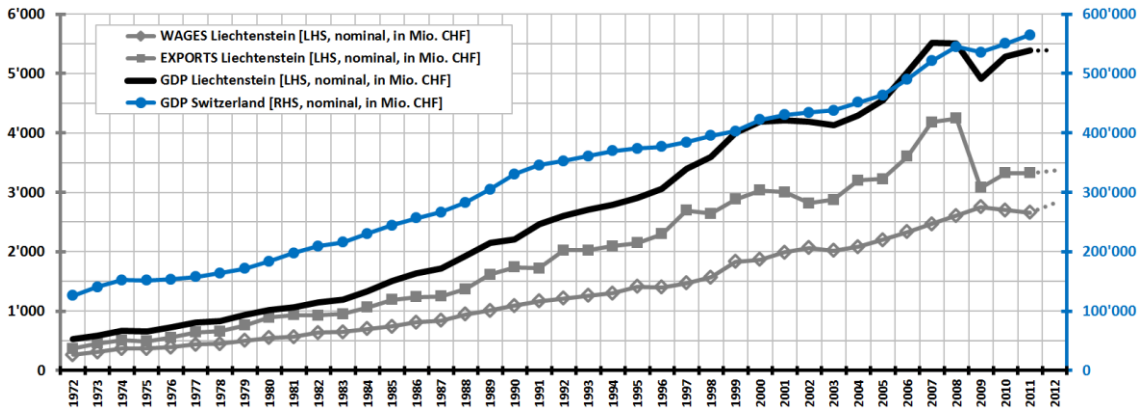

FIGURE 27: Gross domestic product and indicator series

In nominal terms, the GDP of Liechtenstein in 2011 is about ten times greater than in 1972, while the Swiss GDP has risen about 500% during the same time period. For the four considered series, unit root tests have been conducted.

An augmented Dickey-Fuller-Test (DICKEY AND FULLER [1979]) with one-sided p-values after MACKINNON [1996] was applied using the test strategy proposed by ELDER AND KENNEDY [2001] and the information criterion of AKAIKE [1974] for the determination of the lag order in the estimation setting shown below (see remarks in chapter 1.3.2. for the detailed mode of the applied unit root test).[44]

TABLE 33 shows the results of the conducted unit root tests. The null-hypothesis of the existence of a unit root cannot be rejected for the level of all the series, but for the annual differences of all the series.

ADF-Tests	Constant α	Trend t	Lags (AIC)	β (t-Value / *p-Value*)	**I(d)**
log(*GDP*)	Yes	Yes	4	-2.7177 / *0.2359*	**I(1)**
Δlog(*GDP*)	Yes	Yes	4	-4.1191 / *0.0135*	
log(*WAGES*)	Yes	Yes	3	-1.1596 / *0.9087*	**I(1)**
Δlog(*WAGES*)	Yes	Yes	0	-8.1138 / *0.0000*	
log(*EXPORTS*)	Yes	Yes	1	-3.2402 / *0.0917*	**I(1)**
Δlog(*EXPORTS*)	Yes	No	0	-6.1607 / *0.0000*	
log(*GDPCH*)	Yes	Yes	1	-2.5254 / *0.3153*	**I(1)**
Δlog(*GDPCH*)	Yes	Yes	4	-5.0132 / *0.0008*	

TABLE 33: Unit root tests (augmented Dickey-Fuller test)

The unit root tests show that all the used series are integrated of order one. These findings are also supported by other tests such as the tests after PHILLIPS AND PERRON [1988] and KWIATKOWSKI ET AL. [1992]. The variables are being differenced in order to avoid the danger of spurious regression (see GRANGER AND NEWBOLD [1974]),.

Their leading characteristics are investigated to check whether the five used indicator series contain some predictive potential to forecast Liechtenstein's GDP or not. In doing so, causality tests after GRANGER [1969] are carried out. In a first step, the indicator series are tested (each pairwise with the GDP-series). This happens in a univariate setting to explore if the prediction of the GDP can be improved by the inclusion of an indicator series compared to the prediction only

[44] For the justification of the chosen approach see NEUSSER [2006, pp.112-115].

applying the dynamics of the GDP's own past (only lagged variables of GDP itself). Thus, it is basically a F-Test for all the $\beta_1, \beta_2, \ldots, \beta_l$ in the following equation:

$$\Delta\log(GDP_t)=\alpha_0+\alpha_1\cdot\Delta\log(GDP_{t-1})+\ldots+\alpha_l\cdot\Delta\log(GDP_{t-l})$$
$$+\beta_1\cdot\Delta\log(INDICATOR_{t-1})+\ldots+\beta_l\cdot\Delta\log(INDICATOR_{t-l})+\varepsilon_t$$

The causality test is also conducted in a multivariate framework, where it has been tested whether all the phis Φ_{12}, Φ_{13}, and Φ_{14} are significantly different from zero (considering the lag-order one up to order four):

$$\begin{bmatrix} \Delta\log(GDP_t) \\ \Delta\log(WAGES_t) \\ \Delta\log(EXPORTS_t) \\ \Delta\log(GDPCH_t) \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \end{bmatrix} + \begin{bmatrix} \Phi_{11}(L) & \Phi_{12}(L) & \Phi_{13}(L) & \Phi_{14}(L) \\ \Phi_{21}(L) & \Phi_{22}(L) & \Phi_{23}(L) & \Phi_{24}(L) \\ \Phi_{31}(L) & \Phi_{32}(L) & \Phi_{33}(L) & \Phi_{34}(L) \\ \Phi_{41}(L) & \Phi_{42}(L) & \Phi_{43}(L) & \Phi_{44}(L) \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ u_{4t} \end{bmatrix}$$

The results of both the univariate and the multivariate Granger-tests and the correlation of the absolute annual changes of the variables are shown below:

	Correlation with dlog(GDP)	Granger-Causality to dlog(GDP): P-Value of F-Test up to Order *l*				Multivariate Granger-Causality (Lag-Order *l*=1)
		l =	*l* = 2	*l* = 3	*l* = 4	
dlog(WAGES)	0.5913	0.4693	0.4765	0.5550	0.8274	0.2764
dlog(EXPORTS)	0.8010	0.4696	0.4141	0.6260	0.6454	0.4219
dlog(GDPCH)	0.5902	0.8167	0.7104	0.8535	0.8664	0.7379

TABLE 34: Granger causality tests of indicators and gross domestic product

The tests for Granger-causality indicate that the used indicator variables feature only poor leading properties to Liechtenstein's GDP. The cross-correlations of the variables in log-differences are very low. Therefore an ordinary vector autoregressive model in the tradition of SIMS [1980] and different multiple univariate models using lags do not seem to be fruitful a-priori. Nonetheless, different variants of the approaches have been modelled, estimated and evaluated here. Also, a vector error-correction model after JOHANSEN [1988] is being applied.

1.4.2.2. Model Setup and Estimation Results

Due to the small sample size and other related considerations the maximum applied number of lags in the estimated univariate models (ARMA, "ordinary multiple" and later on ARMAX) and the multivariate models (VAR and VECM) is four.

Measures for goodness-of-fit like the adjusted R^2 and information criteria such as the ones after AKAIKE [1974] (AIC) or SCHWARZ [1978] (BIC) were consulted in the process of the pre-selection within each class of models. Yet, the main focus was on Akaike's information criterion, since it has good properties when it comes to forecasting (where you might prefer rather more variables/lags). Also, it seems to handle small sample sizes better, at least when the corrected AIC is applied (see BROCKWELL AND DAVIS [2002, p.173]). If results were contradicting or doubtful, then also the corrected AIC (AICc) proposed by HURVICH AND TSAI [1989] was computed.[45] The AICc even has better properties when samples are small, as it is the case here. Additional considerations concerning the significance of coefficients, non-autocorrelation of residuals, confidence interval of predictions and prediction errors (the latter was prioritised) were also taken into account. These considerations have already been explained in chapter 1.3.2., when the estimation model for the backcasting of national income was presented.

As it turns out, the forecasts of the ARMA-model, which only applies the reference series, was not satisfactory. Also, due to the weak leading properties of the available

[45] The information criterion after AKAIKE [1974] is defined as follows: AIC= -2log(likelihood)+2k. HURVICH AND TSAI [1989] suggested an alternative version of Akaike's information criterion (with better properties for small samples), the corrected Akaike Information Criterion (AICc): $AIC_c = AIC + \frac{2k(k+1)}{n-k-1}$. The AICc applies an additional penalty on the number of parameters. The software EViews computes a slightly modified version of Akaike's criterion: $AIC_{eviews} = -2\left(\frac{\log(likelihood)}{n}\right) + 2\left(\frac{k}{n}\right)$. Hence, applying the information criterion generated by EViews, the original AICc is obtained via the following equation: $AIC_c = AIC_{eviews} \cdot n + \frac{2k(k+1)}{n-k-1}$. See also BURNHAM AND ANDERSON [2004] for additional explanations about the AIC and AICc and information criteria beyond them.

indicators, the multiple model and the multivariate approaches such as the VAR-model and the VECM-model (even though Liechtenstein's exports and GDP appear to be cointegrated) did not have good forecasting properties. They suffered from insignificance of the lagged variables' coefficients and featured rather high prediction errors, which were above 3%. This is not very satisfactory for the in-sample evaluation, yet not especially surprising after the Granger-causality tests. However, these predictions were still better than the naïve forecast by a random walk-model, which exhibits a mean percentage prediction error of more than 5%.

Hence, another approach has to be found. An idea, still featuring the low complexity of a benchmark-model, could be an ARMAX-model. In this approach, instead of lagged variables, contemporaneous variables are introduced. These coincident values have to be separately predicted. Fortunately, KOFL generates predictions for the used indicators exports and wages, while forecasts for the Swiss GDP are obtained from the Swiss Economic Institute (Konjunkturforschungsstelle ETH Zürich, KOF).

FIGURE 28 demonstrates the chronology of the applied ARMAX-setting which generates the conditional forecast of Liechtenstein's GDP. The generated forecast is termed "conditional forecast" since it includes predicted values of the indicator series, wages and exports in Liechtenstein and Swiss GDP.

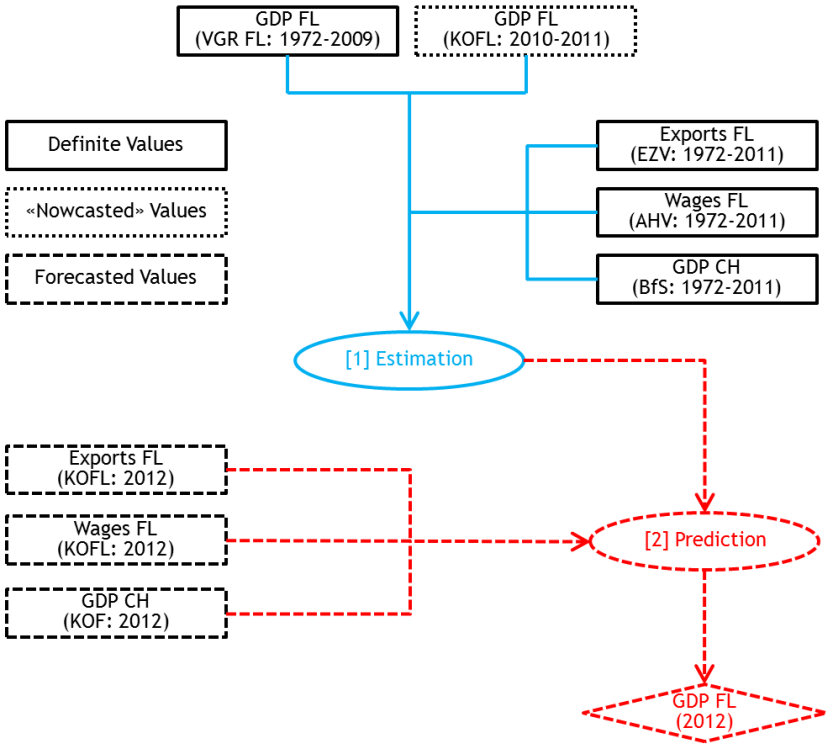

FIGURE 28: Approach of benchmark-model for prediction of Liechtenstein's GDP ("GDP FL")

The ARMAX-approach essentially denotes a time serial model that incorporates ARMA-terms plus independent variables as additional explanatory regressors. The estimated equation of the selected ARMAX-Modell is shown below, also containing time dummies for the years 1990, 1991 and 2008:

$$\begin{aligned}\mathrm{dlog}(GDP_t) = c + \alpha_1 \mathrm{dlog}(GDP_{t-1}) + \cdots + \alpha_l \mathrm{dlog}(GDP_{t-l}) + \beta_1 \mathrm{dlog}(GDPCH_t) + \beta_2 \mathrm{dlog}(EXPORTS_t) \\ + \beta_3 \mathrm{dlog}(WAGES_t) + \beta_4 d90_t + \beta_5 d91_t + \beta_6 d08_t + \varepsilon_t + \delta_1 \varepsilon_{t-1} + \cdots + \delta_q \varepsilon_{t-q}\end{aligned}$$

The dependent variable (the differenced-logarithm of Liechtenstein's GDP to be forecasted) is therefore a function of its own past, some additional variables and the past observed residuals. Only lags for the dependent variable have been incorporated as the independent variables have not turned to be Granger-causal earlier in this chapter. The findings of tentative incorporations of lagged independent variable support this approach. It should also be kept in mind that reduces to an ordinary augmented distributive lag model, if the MA-part, namely the moving average-terms ($\delta_1 \varepsilon_{t-1} + \cdots + \delta_q \varepsilon_{t-q}$), is excluded from the regression.

As competing approach, a static multiple model with ARMA-errors has also been estimated and the best specification within this model class has been compared to the best performing ARMAX-model. The static model with ARMA-errors is of the following form:

$$\mathrm{dlog}(GDP_t) = c + \mu_1 \mathrm{dlog}(GDPCH_t) + \mu_2 \mathrm{dlog}(EXPORTS_t) + \mu_3 \mathrm{dlog}(WAGES_t) + \mu_4 d90_t + \mu_5 d91_t + \mu_6 d08_t + u_t$$
$$u_t = \varphi_1 u_{t-1} + \cdots + \varphi_p u_{t-p} + \varepsilon_t + \gamma_1 \varepsilon_{t-1} + \cdots + \gamma_q \varepsilon_{t-q}$$

The equation of the residual u_t consists of the autoregressive (AR)-part, which accounts for the dependency of the dependent variables on its past observations, and the moving average (MA)-component, which contains lagged forecast errors. The lag order has been evaluated according to the measures mentioned earlier. The maximum lag lengths for AR- or MA-terms within the ARMAX-model and the static model with ARMA-errors was four.

Besides the three known indicator variables "exports", "wages" and "Swiss GDP" and one lagged term of the dependent variable (which lowers the prediction error), three time dummies to account for severe outliers in the years 1990, 1991 and 2008 have been included. To check the estimated regressive relation of the regressand and the regressors, the actual values of the independent and dependent variables have been inserted into the estimation process. Thus, for the calculation of the regression coefficients actual values have been taken, since forecasts for the indicator series do only exist for a few past years.

The estimation results of the chosen specifications of the two model classes (ARMAX-model and static model with ARMA-errors) are shown in TABLE 35 and TABLE 37. For both regressions a constant was included since this proceeding reduced the prediction error in both cases. Within each model class, the best specification was derived in line with the measures already outlined in the beginning of this sub-chapter (1.4.2.2.).

Dependent Variable: dlog(*GDP*)		Adjusted Sample: 1974-2011		
Method: Least Squares		Included Observations: 38 after adjustments		
Variable	**Coefficient**	**Standard Error**	**t-Statistic**	**p-Value**
C	0.0094	0.0062	1.5130	0.1407
dlog(*GDP*(-1))	-0.0750	0.0689	-1.0887	0.2849
dlog(*GDPCH*)	0.4212	0.1752	2.4043	0.0226
dlog(*EXPORTS*)	0.3745	0.0413	9.0679	0.0000
dlog(*WAGES*)	0.3498	0.0803	4.3553	0.0001
D90	-0.0620	0.0198	-3.1322	0.0039
D91	0.0682	0.0191	3.5759	0.0012
D08	-0.0501	0.0189	-2.6576	0.0125
Measures of Fit				
R-squared	0.8897	Mean Dependent Variable	0.0583	
Adjusted R-squared	0.8639	S.D. Dependent Variable	0.0495	
S.E. of Regression	0.0183	Sum Squared Residuals	0.0100	
F-Statistic (p-Value)	34.564 (0.0000)	Durbin's h	1.8287	
Log Likelihood	102.69	Corr. Akaike Info Criterion	-184.35	

TABLE 35: Estimation output of the chosen ARMAX-model

In the ARMAX-model a corrected version of the Durbin-Watson statistic, namely the h-statistic by DURBIN [1970], has been computed due to the fact that a lagged dependent variable is involved.[46]

Dependent Variable: dlog(*GDP*)		Adjusted Sample: 1973-2011 (Backcast: 1969-1972)		
Method: Least Squares		Included Observations: 39 after adjustments		
Variable	**Coefficient**	**Standard Error**	**t-Statistic**	**p-Value**
C	0.0103	0.0042	2.4524	0.0200
dlog(*GDPCH*)	0.5489	0.1406	3.9030	0.0005
dlog(*EXPORTS*)	0.2955	0.0348	8.4999	0.0000
dlog(*WAGES*)	0.2528	0.0732	3.4552	0.0016
D90	-0.0563	0.0156	-3.6094	0.0011
D91	0.0693	0.0129	5.3636	0.0000
D08	-0.0854	0.0152	-5.6302	0.0000
MA(4)	-0.9018	0.0328	-27.491	0.0000
Measures of Fit				
R-squared	0.9181	Mean Dependent Variable	0.0595	
Adjusted R-squared	0.8996	S.D. Dependent Variable	0.0494	
S.E. of Regression	0.0157	Sum Squared Residuals	0.0076	
F-Statistic (p-Value)	49.654 (0.0000)	Durbin-Watson	2.0109	
Log Likelihood	111.25	Corr. Akaike Info Criterion	-201.70	

TABLE 36: Estimation output of the chosen static model with ARMA-errors

The residuals of the model of TABLE 37 without the MA(4)-term seem to feature significant (partial) autocorrelation, which disappears after the incorporation of the MA(4)-term. This setting also turned out to be the best specification of the ARMA-errors regarding the corrected AIC (AICc) and the prediction error.

[46] PARK [1975] showed that the h-statistic is superior to the ordinary Durbin-Watson statistic in the context of small samples.

If the two models are compared, then it appears that the static model with ARMA-errors outperforms the ARMAX-model if the goodness-of-fit (AICc of -201.70 versus -184.35) and the predictive accuracy (mean absolute percentage error of 1.15% against 1.32%) are considered.

The actual and fitted values of Liechtenstein's GDP applying the static model with ARMA-errors and the confidence interval are shown in FIGURE 29 and FIGURE 30. A close fit can be observed.

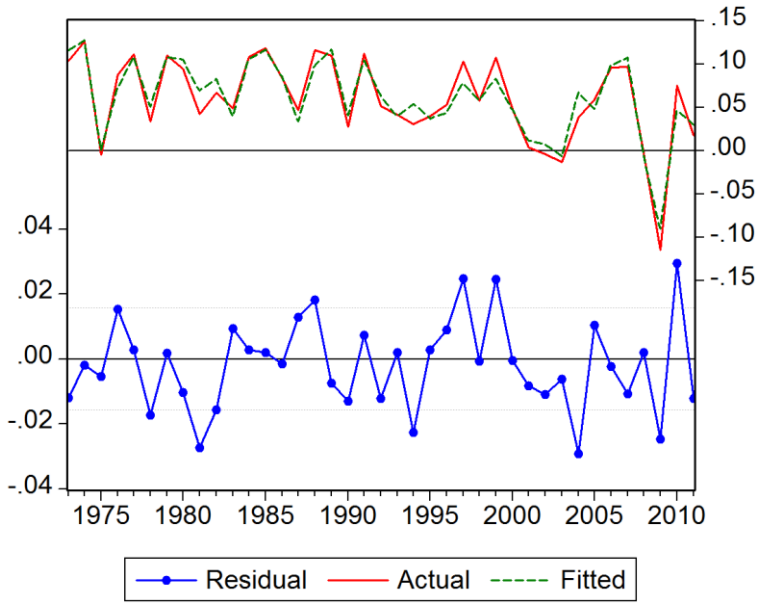

FIGURE 29: Actual and fitted values of dlog(GDP_t)

As it appears, the in-sample prediction error can be reduced to 1.15% (for the years 1973-2011), compared to the univariate and multivariate models without forecasted indicators that featured prediction errors of 3% and higher. The confidence interval of the fitted values of the ARMAX-model has remained stable and narrow. This can be expressed by the reliability indicator of the lower part in FIGURE 30, which was calculated by taking the percentage relation of half of the confidence bound relative to the fitted or predicted value. Only the very volatile years of 1990 to 1991 and 2008 until 2010 show a temporary rise of the reliability indicator that also remains stable and narrow for the out-of-sample forecast in 2012.

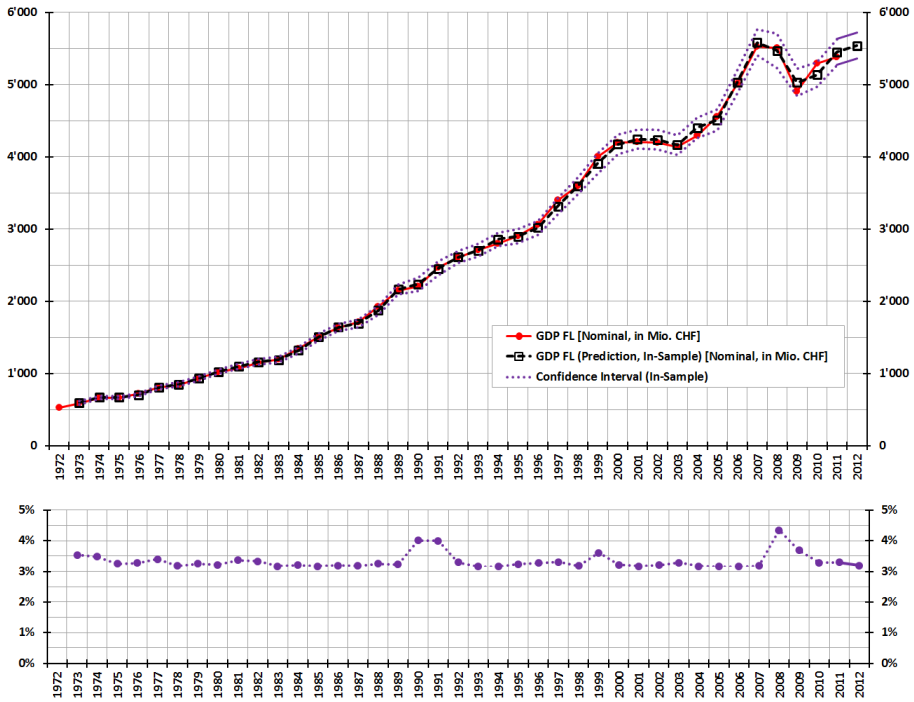

FIGURE 30: Actual and fitted values of GDP (upper graph) and reliability indicator (lower graph)

FIGURE 30 also includes the out-of-sample forecast for the year 2012, which was a true conditional forecast, since the indicators exports, wages and Swiss GDP were predicted separately.

A general remark has to be made here: A true out-of-sample evaluation with real-time data is not possible (evaluating the predictive accuracy out-of-sample accuracy of the different models). In doing so, the indicators should be included as the forecast of each year with the values which were available then. This concerns on the one hand the two nowcasted and continuously revised years of Liechtenstein's GDP and the specific predicted values of the wages, the exports and Swiss GDP. The real time forecasts by KOFL for wages and exports are only available from 2008 until 2012, whereas official GDP-figures are only available until 2009. Hence, there would be only two years for a real-time out-of-sample comparison. Even though the in-sample prediction performance is satisfactory, it would be advisable to continuously retest the model, especially for the out-of-sample forecasting features, when more years than in the current status quo with real-time data for the included variables are available.

The figures by the GDP-nowcasting are very likely to be revised, which can alter the accuracy of the forecast made earlier with unrevised real-time data. But this problem also holds for any kind of forecast attempt for Liechtenstein's GDP, as long as the official publication lag is so big. Both the official flash-estimate (which covers the two years before the prediction takes place) by the Office of Statistics and the nowcasts by KOFL (for the two past years when the prediction happens) are sometimes subject to substantial revisions. Also, as the ARMAX-prediction generates conditional forecasts, the accuracy is mainly dependent on accurate predictions of the included indicator series. But this also applies to any ambitious prediction strategy, also to that by KOFL.

If the out-of-sample forecast of the ARMAX-model with real-time data is comparatively inspected, very similar values to the forecasts by KOFL are observable, which of course are real-time out-of-sample forecasts as well. Thus, the chosen model can be considered as a "cheap" benchmark-model, which can complement the official KOFL forecasting procedure and also serves as an additional detective protection against possible specification or computation errors in the forecasting process.

The small number of observations, even after including the new backward calculations for 1997-1972, was a constantly present challenge in the modelling process. The inspected time period for the evaluation of the out-of-sample prediction errors featured strong volatility and sharp turning points. Furthermore, the high general volatility of the small economy with nominal growth rates between +13% and -10% makes point forecasts complicated and it also enlarges the confidence intervals. Moreover, Liechtenstein's GDP appears to have a potential leading pattern compared to other nation's GDP, meaning that turning points tend to appear earlier, so that many potential international indicators are lagging.

1.5. Conclusions

In chapter 1 of this contribution, several economic data series of Liechtenstein have been backwardly estimated and linked in order to obtain consistent historic time series. The series include the national income from 1954 to 1997, the sectoral and total employment in the 1970s and some years of the 1980s and 1990s and most importantly the gross domestic product from 1972 to 1997. These series can be chained with the official results from the national accounts, which were introduced for the year 1998 and have been published until 2009 so far. Also, a benchmark model has been presented, which can serve as a supporting supplement to the official annual GDP-forecast for Liechtenstein's economy which is carried out by KOFL.

As the GDP-series and the employment have now been definitely computed, one could consider re-estimating and potentially revising the data points of national income that have been determined by the use of a regression, when more official figures regarding the national income will be available in the future years. A next step would be to retropolate gross domestic product in a similar estimative manner as the retropolation model for the national income. In BRUNHART, KELLERMANN AND SCHLAG [2012] the approach developed in this dissertation has already been applied and GDP-figures for the years 1954 until 1971 have been obtained and used for the analysis of Liechtenstein's long term-growth. The reference series for this retropolation (using indicator series) was computed in a preliminary version of results applying the computation method developed and introduced in chapter 1.4. for the years from 1972 to 1997. Now, as definite estimates of GDP-figures (which were very slightly revised compared to the prementioned paper) have been presented in this dissertation, the estimation model may be updated and fully methodically outlined in the near future. Also, the actual predictive accuracy of the already mentioned benchmark forecasting model for annual GDP should be

evaluated every year, once additional observations for the out-of-sample evaluation with real-time data become available.

Also very interesting in the context of the analysis and prediction of Liechtenstein's business cycle and the inspection of other economic matters would be sub-annual figures of Liechtenstein's GDP that only annually exist so far. A method for the generation of quarterly GDP-figures and first results from 1999Q1 until 2011Q4 will be presented later on (in chapter 2.4.).

A nowcasting model for Liechtenstein's gross national income would be an important supplement to the existing nowcasts of gross domestic product. The gross national income is also of high economic and analytical relevance. Gross national income figures are for example required by Liechtenstein's Office of Foreign Affairs in order to calculate the annual percentage share of Liechtenstein's Official Development Assistance (ODA) usually measured in relation to the gross national income.[47] Also, several national contributions to international organisations are based on gross national income (see KELLERMANN AND SCHLAG [2005]). Earlier accessible GNI-figures (with a shorter publication lag) could also be interesting for preliminary calculations related to the division of certain kinds of taxes and tariffs between Switzerland and Liechtenstein (this division has been outlined in chapter 1.4.1.3.).

Other examinations, that are now possible with the prolonged GDP-series and which have been started but have not had space in this dissertation, are: the suspected leading behaviour of Liechtenstein's economy relative to its neighbours and the analysis whether a synchronization of business cycle with its neighbouring

[47] That is why the author has provided the Office of Foreign Affairs nowcasts for the year 2010 by setting up a first version of a nowcasting model with two linked regressions, which takes advantage of the now five observations longer time span of computed national income figures (1993-1997 after the national accounting scheme and 1998-2009 official figures) and the correlation of national income with gross national income. Before this model will be presented to the public, it will be assessed in a third run, when new official results are released in December 2012, or simply just waited until some new annual observations are available.

nations has taken place or not (with respect to the long-run growth path, the evolution of the volatility, and a potential convergence), also checking for structural breaks in the historic economic time series.[48]

[48] It has already been found that there is certain persistence of shocks, as all the inspected time series for Liechtenstein's economy follow a unit root process (random walk), also the newly estimated GDP.

1.A. Appendix

1.A.1. National Income Account: Interests of Residents

The interests of residents are an important element of the private households' property income. These interests have to be roughly approximated due to the lack of appropriate detailed statistics. This was also done by the governmental financial unit and in the first preliminary versions of the official national accounts. In a first stage, the interest rates for different kinds of creditors (deposits, savings, obligations) have to be collected and averaged. The interest rates are published in the official banking statistics of the Office of Statistics. These figures are on a quarterly base. The mean is being calculated in order to get averaged annual interest rates.

Interest Rates							
In percentage		1993	1994	1995	1996	1997	1998
Fixed Deposits	3 months	4.29	3.23	2.40	0.95	0.87	1.00
	6 months	4.14	3.27	2.55	1.03	0.97	1.06
	12 months	3.86	3.36	2.69	1.12	1.05	1.18
	Average	4.10	3.28	2.55	1.03	0.96	1.08
Savings Book	Savings Deposits	4.17	3.33	3.01	1.94	1.55	1.29
	Young People's Savings	4.65	3.79	3.47	2.54	2.09	1.77
	Old People's Savings	4.63	3.67	3.30	2.34	1.84	1.52
	Building Society's Savings	4.81	4.00	3.69	2.25	1.88	
	Average	4.56	3.70	3.37	2.27	1.84	1.53
Deposits		3.22	2.25	1.97	1.03	0.80	0.55
Creditors at Sight		0.50	0.50	0.80	0.59	0.51	0.30
Obligations	3-4 years	4.48	4.10	4.02	2.81	2.29	2.19
	5-6 years	4.71	4.30	4.32	3.39	2.82	2.60
	7-8 years	4.79	4.44	4.55	3.87	3.27	3.01
	Average	4.66	4.28	4.29	3.36	2.79	2.60

TABLE 37: Interest rates for different creditors

The monetary amounts of all the relevant types of creditors have to be gathered as well. The interest rates are listed in TABLE 37 and the amounts of creditors are shown in TABLE 38. These compiled figures concern values on the 31st of December of each considered year. As the components of the national income rely on the gained income only of residents (in contrast to the gross domestic product), domestic interests in Liechtenstein of non-residents need to be deducted. Hence,

one is mainly interested in the second part of TABLE 38. Unfortunately, the official statistics do not separate the interests of Liechtenstein and Swiss citizens (denoted by CH+FL in the table).

Interest-Bearing Liabilities								
By end of year, in 1'000'000 CHF		1992	1993	1994	1995	1996	1997	1998
All	Creditors at Sight	3'075.9	3'883.0	2'695.4	3'092.5	5'182.5	6'436.4	7'688.2
	Creditors Payable on Maturity	11'875.3	10'723.8	12'519.8	11'255.4	10'867.1	10'876.9	10'897.5
	Savings Deposits	1'311.3	2'307.3	2'845.0	3'699.6	4'588.5	4'792.8	4'631.3
	Deposits	118.8	183.641	159.5	268.9	330.1	4512.0	427.3
	Sub-Total	*16'381.3*	*17'097.7*	*18'219.7*	*18'316.5*	*20'968.2*	*22'558.1*	*23'644.2*
	Medium Term Bonds	1'656.1	1'784.9	1'717.4	2'101.0	2'157.1	1'756.1	1'640.9
CH+FL	Creditors at Sight	2'293.0	2'859.1	2'022.6	2'331.3	3'630.2	4'651.8	5'402.3
	Creditors Payable on Maturity	8'099.0	6'672.9	7'649.7	6'653.3	6'001.1	6'050.5	5'844.2
	Savings Deposit	957.3	1'755.7	2'211.5	2'887.5	3'604.0	3'714.0	3'650.4
	Deposits	87.9	144.3	119.4	210.2	252.9	365.3	320.8
	Sub-Total	*11'437.1*	*11'432.1*	*12'003.1*	*12'082.2*	*13'488.2*	*14'781.6*	*15'217.8*

TABLE 38: Amount of creditors

The amounts of creditors are published annually on due date 31st of December. Yet, as the amount trough-out the year is more interesting, the annual average is calculated by simply taking the mean of the precedent and the current year.

Interest-Bearing Liabilities FL+CH (Yearly Average, in 1'000 CHF)	1993	1994	1995	1996	1997	1998
Creditors Payable on Maturity, Fixed Deposits	11'299'551	11'621'759	11'887'587	11'061'296	10'872'029	10'887'212
Savings Deposits	1'356'514	1'983'600	2'549'475	3'245'727	3'659'001	3'682'192
Deposit	116'113	131'850	164'805	231'570	309'113	343'068
Medium Term Bonds, Bonds	1'720'501	1'751'186	1'909'234	2'129'094	1'956'615	1'698'477
Creditors at Sight	3'479'440	3'289'178	2'893'944	4'137'517	5'809'434	7'062'253

TABLE 39: Interest bearing liabilities

After having derived the annual averages of the interest bearing liabilities the average received interests for the five different groups of liabilities can now be calculated by making use of the compiled interest rates of TABLE 37. The received interests by citizens of Liechtenstein and Switzerland (occurred in Liechtenstein) can then be obtained:

Interests FL+CH (Yearly Average, in 1'000 CHF)	1993	1994	1995	1996	1997	1998
Creditors Payable on Maturity, Fixed Deposits	462'717	381'581	302'539	114'208	104'371	117'854
Savings Deposits	61'891	73'368	85'854	73'556	67'143	56'276
Deposits	3'733	2'967	3'243	2'374	2'465	1'878
Medium Term Bonds, Bonds	80'132	74'936	81'986	71'484	54'638	44'175
Creditors at Sight	17'397	16'446	23'152	24'204	29'628	21'187

TABLE 40: Interests of interest bearing liabilities

The second main step is now to calculate the amount of interests of Liechtenstein's residents. As the annual shares are unknown, the financial unit of the government used approximations of the shares, which are labelled in the following table and used for the last step in the determination of the interest income of residents.

Domestic Shares of Interests FL (Yearly Average, in 1'000 CHF)	Assumed Shares	1993	1994	1995	1996	1997	1998
Creditors Payable on Maturity, Fixed Deposits	55%	254'494	209'870	166'396	62'814	57'404	64'820
Savings Deposits	85%	52'607	62'363	72'976	62'523	57'071	47'835
Deposits	85%	3'173	2'522	2'756	2'018	2'095	1'597
Medium Term Bonds, Bonds	55%	44'073	41'215	45'092	39'316	30'051	24'296
Creditors at Sight	75%	13'048	12'334	17'364	18'153	22'221	15'890
TOTAL: Interest Income of Residents		367'395	328'304	304'584	184'824	168'843	154'437

TABLE 41: Domestic shares of interests

The interests of residents are now determined and can then be used as main element of the property income of the private households as a sub-account in the computation process of the national income account.

1.A.2. Table of Log-Model (Retropolation of National Income)

As outlined in chapter 1.3.2., the regression model used for the interpolation of the national income is estimated with the variables in logarithms and in differenced logarithms and then both types are comparatively evaluated. The estimation output in dlogs is displayed in chapter 1.3.2. (TABLE 21), while the output of the inferior log-model are presented in the following, in TABLE 42.

Dependent Variable: log(*NATIONAL INCOME*)		Sample (adjusted): 1960-2009		
Method: Least Squares		Included Observations: 27 after adjustments		
Variable	**Coefficient**	**Standard Error**	**t-Statistic**	**p-Value**
LINEAR TREND	-0.0171	0.0073	-2.3313	0.0316
log(*NATIONAL INCOME*(-1))	0.3454	0.1416	2.4389	0.0253
log(*WAGES*)	0.3285	0.1809	-1.8156	0.0861
log(*FOREIGN SALES*)	0.3741	0.1301	2.8764	0.0100
log(*BANKING ASSETS*)	0.6419	0.1519	4.2261	0.0005
log(*GNI CH*)	-0.0908	0.0477	-1.9019	0.0733
D60	0.1627	0.0500	3.2533	0.0044
D61	0.1044	0.0409	2.5514	0.0200
D09	-0.1797	0.0477	-3.7675	0.0014
Measures of Fit				
R-squared	0.9997	Mean Dependent Variable	6.8069	
Adjusted R-squared	0.9995	S.D. Dependent Variable	1.5145	
S.E. of Regression	0.0340	Akaike Info Criterion	-3.6638	
Sum Squared Residuals	0.0208	Schwarz Criterion	-3.2319	
Log Likelihood	58.4614	Durbin-Watson Statistic	1.8981	

TABLE 42: Estimation output of the model in log-levels

1.A.3. Generating Consistent Time Series of Employment

As a consequence of the chosen approach of the retrospective estimation of Liechtenstein's GDP, annual employment figures for the years 1972-2008 are required, regarding both total and sectoral figures divided into the sectors "agriculture/households", "industry/manufacturing", "financial services" and "other services".

The official statistics of Liechtenstein's national Office of Statistics provide total employment figures for the years 1930, 1941, 1950, 1955, 1960, 1965, 1970, 1975 and 1980-2009. Sectoral employment is only available for the years 1955, 1960, 1965, 1970, 1975 and 1980-2010, whereas only for the years 1955, 1965, 1975, 1986-1991 and 1995-1996 and 1998-2010 the service sector has been divided into financial and other services. The official employment figures for the year 1955, 1965 and 1975 are compiled via the census of enterprises and are therefore not perfectly comparable to the ordinary employment statistics. However, they still serve as important indicators. In the following explanations, the focus will be mainly on data from 1970-2009.

Along with this dissertation, consistent time series for sectoral and total employment are generated, which not only enable the backward estimation of Liechtenstein's GDP, but also extend, as a side-product of the backward estimation, the database for future economic (historical) analyses. Additionally, an obvious mistake or misprint featured in the official statistics concerning the sectoral employment in the 1981 is being revised: The reason for the implausible jumps in the share of employment between industry and financial services could not be traced back by the national Office of Statistics after a request by the author, but these jumps seem to be rather of mistaken nature than being just an unusual (but correct) outlier.

The estimation procedure differs for periods of years, usually employing interpolation and reconciliation (with respect to the total constraints) and usage of different data sources serving as indicators, control reference or benchmark. Thus, the constructed figures result from a deliberate and iterative proceeding combining interpolation, reconciliation and use of indicators. The thereby used information sources (both official and scientific documents, but also other archived data resources) were subject to an extensive and long-lasting gathering process from information sources and should therefore reflect all appropriate data, which are arguably accessible to the public. TABLE 43 shows the relevant data sources, which have been used for compiling the consistent employment time series.

Issuer and source of data	Provider of data	Data	Years
National Office of Statistics (1980): Survey of companies on development of employment[49]	National Office of Statistics	Sectoral and total employment (domestic)	1974, 1976, 1978, 1980
National Office of Statistics (2010): Employment statistics	National Office of Statistics	Sectoral and total employment (domestic)	1980-2009
National Office of Statistics (1980): Statistical yearbook	National Office of Statistics	Sectoral and total employment	1980
National Office of Statistics (1977, 2010): Statistical yearbook	Liechtenstein Chamber of Commerce and Industry	Employment of industrial companies	1965-1979, 1992-2008
National Office of Statistics (2008): Banking Statistics	Liechtenstein Bankers Association	Employment of banks	1970-2007
Liechtenstein government: Annual governmental report (several years)	National Office of Statistics	Inward commuters	1980-1985
BATLINER [1966]	Liechtenstein Chamber of Commerce and Industry	Employment of industrial companies	1955-1964
National Office of Statistics (several years): Statistical yearbook	National Office of Statistics	Sectoral and total places of employment according to census of enterprises (domestic)	1965, 1975, 1985, 1991, 1995
National Office of Statistics (1987-1999): Places of employment	National Office of Statistics	Detailed sectoral and total employment (domestic)	1987-1999

TABLE 43: Sources for the estimation of total and sectoral employment

1.A.3.1. Employment Industry/Manufacturing

The starting point of generating figures for the employment in industry/manufacturing is to compile consistent annual figures of employment in the industrial (production) sector from 1970 until 1980. As already stated earlier, for industrial employment the only missing years in Liechtensteins official statistics are

[49] See OFFICE OF ECONOMIC AFFAIRS [1980].

1971-1979 and the year 1981 has to be revised. Fortunately, there is a data series, which can serve as a good indicator for the development of industrial employment: The Liechtenstein Chamber of Commerce and Industry (german abbreviation: LIHK for Liechtensteinische Industrie- und Handelskammer) supplies annual figures covering their member companies. It was possible to obtain annual figures of employment of the industrial member companies back to the year 1950. These figures include the most important industrial companies, which cover more than two third of the whole industrial employment in Liechtenstein. Thus, they are an ideal proxy for industrial employment.

To estimate appropriate figures for the industrial employment by the usage of the LIHK-proxy a special interpolation-method is developed, introduced and used here: In a first step, the available industrial employment figures of the years 1950 (3'363 employees), 1960 (5'479), 1970 (7'097), and 1980 (8'203) are being linearly interpolated. The same linear interpolation is carried out as well for the indicator series (figures by the LIHK) and applied for the same benchmark years.

In a second step, for each year (1951-1959, 1961-1969, 1971-1979) the percentage deviation of the linearly interpolated figures from the actual indicator series' figures is being calculated. These percentage deviations are then used to revise the interpolated reference series (the estimated industrial employment), assuming a similar relative movement of the reference and the indicator series.

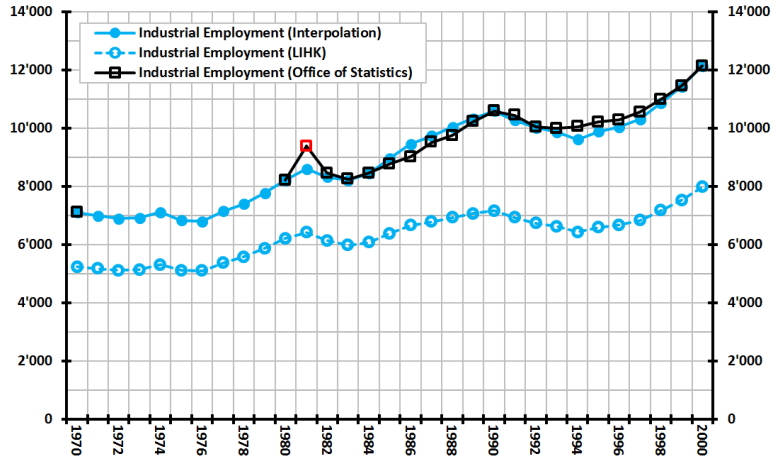

FIGURE 31: Industrial employment in Liechtenstein (employed people by the end of year)

In a third step, in order the get an idea of the adequacy of the estimates, the same procedure is done for the years 1980 until 2000, using 1980, 1990 and 2000 as the benchmark years for the interpolation.

In a fourth step, these estimates are evaluated in comparison to the official figures available from 1980 on. FIGURE 31 shows the estimated sectoral employment figures in the industry sector together with the official figures. By visually inspecting the time period from 1980 to 2000, it is evident that the chosen estimation procedure is reliable. This result is also supported by the fact that the absolute difference between the official and the present estimates is on average 1.86% (for the evaluated years 1982-1989 and 1991-1999). The figure also shows the inaccurate outlier in the year 1981 in the official statistics already mentioned earlier, which has been replaced here by the estimated value (the outlier to be revised is marked by the red casket).

1.A.3.2. Employment Financial Services and Other Services

After having obtained a consistent series of industrial employment (1970-2009) the next goal would be to derive a series which features employment figures in the service sector separated for financial services and other services. While figures for

total services are available for the years 1970 and 1980-2009 (the few covered years before 1970 are left aside), separated values are only available for the years 1986-1991, 1995-1996 and 1998-2009.

To attain consistent results, the definition of the sub-sectors included into the financial sectors has been kept consistent for the whole time span. These sub-sectors are: banking services, insurance services, legal and tax advice services and accounting services. The procedures chosen for the estimation of detailed figures of the service sector differ for different considered time periods:

- *1986 until 1991 and 1995 until 1997*: There are archived statistics accessible from 1986 until 1997 which involve employment of about 17 sub-sectors despite the fact that in the official national statistics the services sector is only available as total. Thus, employment within the sectors financial services and other services can be directly calculated. For the years 1992-1994, some minor additional approximations had to be made, because the exact classification of the sub-sectors varied in the documents.

- *1980 until 1985*: For these six years total employment, agricultural employment, industrial employment and total service employment are known. Therefore, the only aspired additional information would be how total service employment is distributed between financial services and other services. For this estimation purpose, two additional data sources are used: statistics on inward commuters (by sub-sectors) and on employed Liechtenstein residents (by sub-sectors).[50] The total of both serves as a good measure for the sub-sectoral domestic employment mix.[51] Aggregating the

[50] Sources are the annual report of Liechtenstein's Government (1980-1985) and the Statistical Yearbook of the national Office of Economic Affairs (1980-1985).

[51] To be very precise, the outward commuters should have been deducted from the sum of inward commuters and residents. Yet, the number of inward commuters is not available for these years, but this fact should be rather neglectable: The number of outward commuters plays a comparably minor role (1985: 12'800 employed residents, 4'290 inward commuters, 850

relevant sub-sectors as well to all other services and all financial services, and adding up inward commuters and employed residents, the relevant percentage ratio of financial services relative to other services can be obtained.

- *1970 until 1979*: For these ten years only industrial employment is known. Industrial employment has been estimated earlier and exhibits the largest employment share of all sectors. Total employment, agricultural employment and total service employment are only available for 1970, 1975 and 1980. In a first step, total employment is being estimated, since it serves as the summation constraint in the reconciliation process. In doing so, a survey of the OFFICE OF ECONOMIC AFFAIRS [1980] regarding total and sectoral employment for the years 1974, 1976, 1978 and 1980 is taken into account. Even though this survey is not perfectly comparable to the official figures (this is visible in 1980, when both figures, official and those coming from the survey, exist), it supplies a good indicator for the development of total employment since around 75% of all domestic workplaces are covered in the survey. It is therefore justified to calculate the percentage difference (of total employment) between 1980 and 1978, 1980 and 1976, and 1980 and 1974 and to apply these differences to the official figure in 1980, in order to obtain approximated values for 1978, 1976, and 1974. The remaining years 1979, 1977, 1975, and 1973-1971 are linearly interpolated. Then, in a second step, agricultural employment is estimated. Official and consistent agricultural employment figures are disposable for the years 1970 and 1980-2009. Inspecting the data, two basic remarks can be stated: The share of agricultural employment against total employment is on the one hand small and on the other hand monotonically decreasing (in linear shape): From 4% in 1970 to 1.25% in 1998. It is therefore appropriate to linearly interpolate the years between 1970 and 1980. Having already derived consistent series of

outward commuters) and does not seem to have a substantial different sub-sectoral employment mix anyway.

total employment, industrial employment and agricultural employment (all for the years 1970-1980), employment in the services sector can be calculated as residual. The remaining task is now to segment employment in the services sector into financial services and other services, assuming a monotonous change of the employment mix between the two sectors. The ratio financial services/other services is 0.3145 in 1980 and 0.2830 in 1970. The ratio in the year 1975 is also known: 0.2934.[52] The ratios for the remaining years 1971-1974 and 1976-1979 are linearly interpolated.

Subsequently, the annual total and sectoral employment figures (which relate to the 31st of December for each year) are modified into yearly averages. These yearly averages are computed by taking the average of the figure regarding the end of the considered year and the figure regarding the end of the previous year.

1.A.3.3. Employment Agriculture and Sum of Sectors

Liechtenstein's official employment figures concerning the agriculture sector exist on an annual base from the year 1980 on. Since the share of employment in agriculture is also known the numbers of employed people in the agricultural sector for the years 1971-1979 are obtained by linearly interpolating the percentage share agricultural employment/total employment. This proceeding is fairly reasonable as the share of agricultural employment has diminished in a very continuous fashion during the previous decades and can be approximated well by a linear time trend. Additionally, the share of agricultural employment is relatively low and not of primary interest regarding the investigations and estimations in the course of this doctoral project.

[52] Sectoral and total working places of employment regarding 1975 are according to the census of enterprises (domestic) carried out by the national Office of Economic Affairs. The working places figures of the census of enterprises are not perfectly identical with those of the employment figures in the employment statistics but comparable (especially the share of the different sectors).

In TABLE 44 the already available figures from various official sources and the approximated ones are listed showing the number of employed people by the end of the respective year. Newly generated figures within the table are written in light-grey *italics*. It should be noted that annual averages (mean of current and previous year) have been calculated before they were applied in the computation process of Liechtenstein's GDP for 1972 until 1997. Figures for the total and the sectoral employment (divided into these four sectors) of more recent years from 1998 on are easily accessible via the official national accounts (Volkswirtschaftliche Gesamtrechnung Liechtenstein, VGR FL) published by the Office of Statistics.

Employment (31.12.)	Industry and Manufacturing	Financial Services	Other Services	Agriculture	TOTAL
1970	7'097	835	3'172	465	11'569
1971	*6'986*	*915*	*3'401*	*460*	*11'762*
1972	*6'886*	*994*	*3'620*	*454*	*11'955*
1973	*6'909*	*1'048*	*3'741*	*449*	*12'148*
1974	*7'107*	*1'065*	*3'726*	*442*	*12'340*
1975	*6'834*	*1'142*	*3'919*	*428*	*12'323*
1976	*6'800*	*1'163*	*3'929*	*414*	*12'306*
1977	*7'142*	*1'268*	*4'217*	*425*	*13'052*
1978	*7'394*	*1'396*	*4'574*	*435*	*13'799*
1979	*7'775*	*1'445*	*4'663*	*435*	*14'319*
1980	8'203	1'484	4'718	435	14'840
1981	*8'594*	*1'559*	*4'703*	429	15'286
1982	8'446	*1'594*	*4'906*	377	15'323
1983	8'242	*1'607*	*4'925*	389	15'163
1984	8'451	*1'745*	*5'034*	385	15'615
1985	8'769	*1'897*	*5'197*	377	16'240
1986	9'012	2'214	5'477	375	17'078
1987	9'514	2'542	5'656	396	18'108
1988	9'737	2'554	5'958	351	18'600
1989	10'221	2'699	6'022	354	19'296
1990	10'581	2'807	6'166	351	19'905
1991	10'435	2'847	6'807	355	20'444
1992	10'037	*2'847*	*6'817*	336	20'037
1993	9'982	*3'008*	*7'419*	347	20'756
1994	10'052	*3'119*	*7'590*	348	21'109
1995	10'199	3'303	8'080	350	21'932
1996	10'273	3'442	8'464	344	22'523
1997	10'545	*3'351*	*8'994*	301	23'191

TABLE 44: Official and approximated number of employed people (total/sectoral) in Liechtenstein

Calculating the annual averages in TABLE 44 and linking these values with the data of the national accounts from the years 1998 until 2009, one obtains the graphical

representation of Liechtenstein's sectoral (left hand scale of FIGURE 32) and total employment (right hand scale of FIGURE 32).

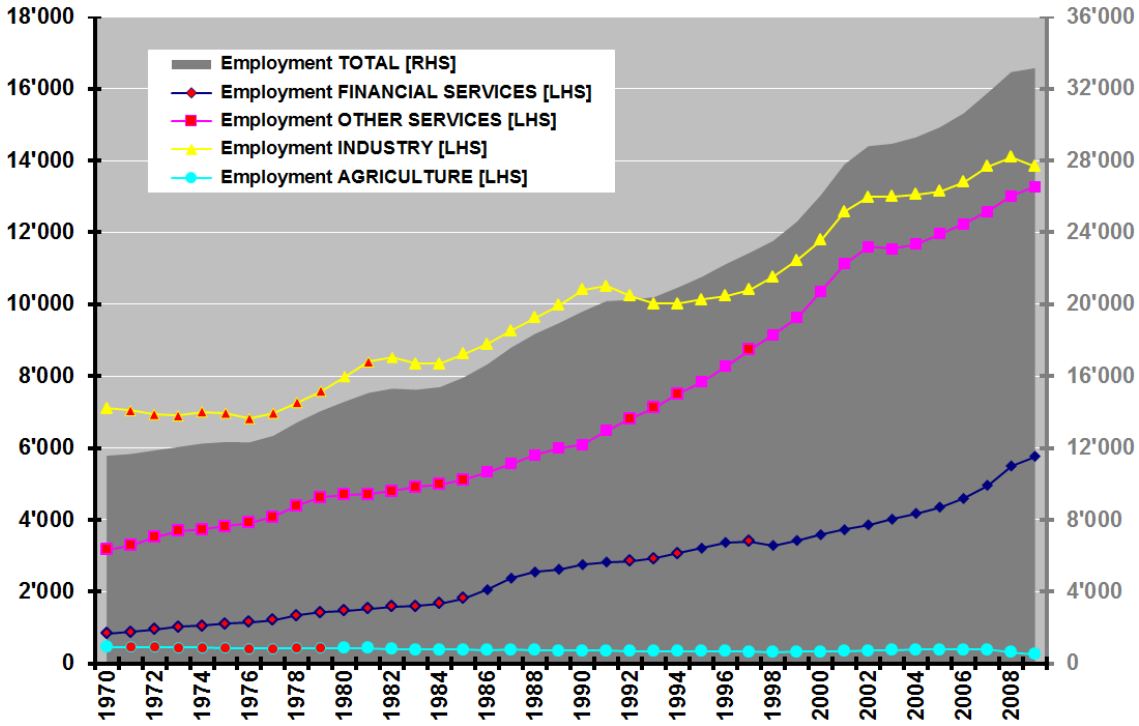

FIGURE 32: Sectoral/total employment in Liechtenstein (annual averages of employed people)

2.

The New Composite Index "KOFL KonSens": An Indicator for Liechtenstein's Sub-Annual Business Cycle[#]

[#] This part of the dissertation (chapter 2) is planned to be published in German as *KOFL Working Paper* (working paper series issued by the Liechtenstein Economic Institute, KOFL).
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2.1. Introduction

Business cycle indicators play an important role in the analysis and prediction of the development of economic short-term fluctuations. Thereby is not only the evolution of the individual variables, such as real GDP or unemployment, of relevance. Their common movement into a certain direction can also provide an insightful analysis. The KOFL KonSens, that shall be introduced in this contribution, represents a composite business cycle indicator for Liechtenstein's economy and incorporates several individual indicators. It combines twenty data series with business cyclical relevance for Liechtenstein and bundles different empirical economic signals into a uniform picture. On the one hand, the name "KOFL KonSens" reflects on the one hand the conception of a business cycle as a consensus of several business cycle impulses.[53] BURNS AND MITCHELL [1946] used the term "business cycle as a consensus", which depicts a view which has been shared by various economists that have dealt with business cycles. In the tradition of this view, that has also been advocated by the well-known National Bureau of Economic Research (NBER), also MOORE [1950, p.13], another pioneer in this field, noted:[54] „Most economic activities, on any reasonable definition, expand and contract roughly in unison. This consensus can be demonstrated in various ways." On the other hand, the name "KonSens" is an abbreviation of "Konjunktur-Sensor", the German expression for "business cycle sensor", and therefore stands for a composite indicator that shall serve as a sensorium for the situation of the business cycle of Liechtenstein's national economy.

Apart from the fact that the KOFL KonSens simplifies the for the business cycle relevant inquiries of many different sets of data from different sources and publications (this data may also feature different dimensions, frequencies and units),

[53] "Konsens" is the German word for consensus, whereas "KOFL" is the abbreviation for Konjunkturforschungsstelle Liechtenstein (KOFL Liechtenstein Economic Institute).

[54] Further contributions in the field of business cycle research, especially by applying business cycle indicators, are for example OPPENLÄNDER [1996], THE CONFERENCE BOARD [2001] or ZARNOWITZ [1992].

the usage of a composite indicator has additional, methodological advantages compared to the exclusive focus on individual indicators: Volatility is being reduced, matching information combined, and a better transmission of business cycle impulses achieved. The measurement of the business cycle movements, separated from the long-term growth-trend and seasonal influences, is targeted (this is usually the case in business cycle research). As an additional contribution beyond the project itself, the relevant methods in this context will be presented and explained in thorough detail in the following chapters and in the appendix (2.A.).

All the considered individual indicators of the KOFL KonSens are available until the first quarter of 2012, with the exception of the companies' sales data gathered by Liechtenstein's national tax administration, which are accessible until the fourth quarter of 2011. Since these data are of high importance, in a first step, the KOFL KonSens is only computed until the fourth quarter of 2011 to illustrate the methodology and already present first business cycle analytical results for the previous 13 years. In the future a smaller publication lag is desired, in dialogue with the tax administration, to enable a prompter computation (realistic would be around 2 months) and therefore an earlier business cycle analysis.

After the generation of the time series of quarterly figures of the KOFL KonSens for the investigated time frame (first quarter of 1999 until fourth quarter of 2011), a econometric prediction model can be developed in an subsequent future work step. Then, the KOFL KonSens will not only be a tool for the prompt analysis of the business cycle situation but also a base instrument permitting a qualitative forecasting of future tendencies of Liechtenstein's economy. Well-known composite leading indicators, such as the KOF Barometer or the OECD Leading Indicator (which are presented by GRAFF [2006], NILSSON [1987] and GYOMAI AND GUIDETTI [2008]), follow a direct mode by exclusively identifying indicators with a statistical lead and aggregating them to a composite indicator. In contrast to this direct way, the KOFL KonSens is generated as an aggregation of coinciding

indicators. Then in a second step, a time serial prediction of the reference series KOFL KonSens takes place, with KOFL KonSens as dependent variable, also incorporating leading indicators in a multiple or multivariate framework. The computation and publication of the KOFL KonSens therefore is a direct contribution to the business cycle analysis and prediction, as it provides both a composite coinciding indicator and at the same time also enables an application for the detection of leading signals of the future business cycle tendency.

The term "business cycle" and related definitions and concepts are being discussed in the next chapter. Chapter 2.3. outlines the actual motivation of the introduction of the KOFL KonSens, while chapter 2.5. includes the methodological steps of its computation. In chapter 2.4., the most important individual indicators of the composite indicator (Liechtenstein's quarterly GDP) will be derived from annual GDP figures in a temporal disaggregation estimation model as Liechtenstein's GDP is only available in annual frequency so far. Chapter 2.6. exhibits the first results for the KOFL KonSens. After the conclusion, all the relevant statistical and mathematical procedures that are relevant for the KOFL KonSens are demonstrated and explained in detail in the appendix, which also features the illustration of all the applied indicators.

2.2. „Business Cycle“: Definition and Measurement

Before we proceed to the goal, method and first results of the KOFL KonSens, it is fruitful to give a short introduction into business cycle analysis and some of its definitions and concepts. In his conversant quote MITCHELL [1927, p.468] defined the term business cycle as follows: “Business cycles are a type of fluctuation found in the aggregate economic activity […]: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; in duration, business cycles vary from more than one year to ten or twelve years…”

The middle-term and particularly the short-term (namely the high frequency) are of main interest in the business cycle analysis and prediction.[55] FIGURE 33 illustrates the conceptual separation of the long-term growth and the short-term fluctuations: The stylized economic output of an economy sinuously swings but steadily grows over time. The difference between the unobservable trend depicted by the black line (long-term growth, potential output) and the actually observed economic output (measured by real GDP) represents the output gap, which can be understood as “business cycle” and hence is of central interest in the context of business cycle research. Positive differences signal booming tendencies, while a negative output gap indicates recessive drifts.

[55] Some parts of this chapter are partially based on BRUNHART [2006].

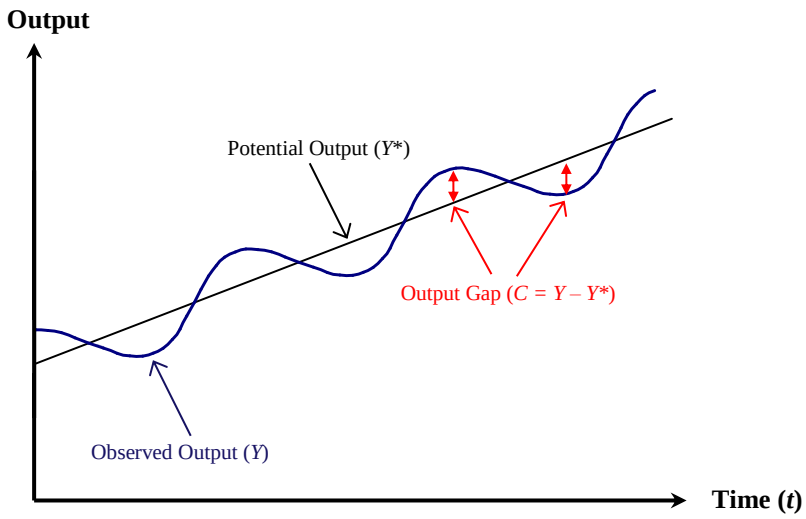

FIGURE 33: Observed output, long-run trend and output gap

Thus, one main task in the course of business cycle analysis is to isolate the short-run cycle from the long-run growth trend. Eliminating the trend with an appropriate procedure the business cycle remains as an amplitude around the potential output Y*, which represents the natural output at "normal" capacity utilization of production factors, as visible in FIGURE 34. The economic time series has to be decomposed into different components to detect the business cycle component.[56]

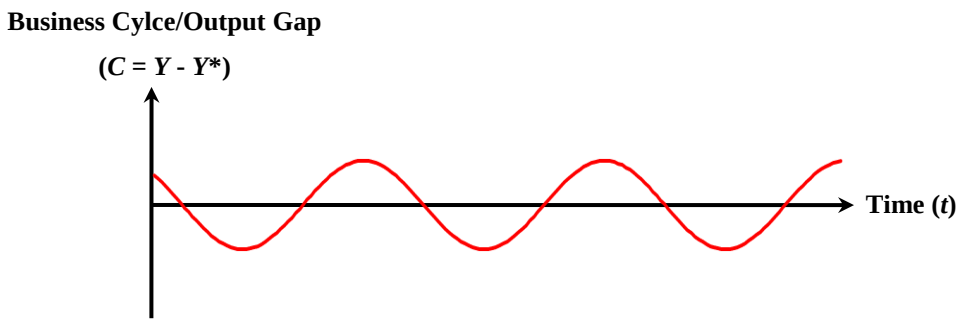

FIGURE 34: Trend-removed, business cyclical amplitude around potential output

There are plenty of other types of data besides the gross domestic product with relevance for the business cycle analysis and which also feature a typical economic

[56] In time series analysis concerning applied economic research it is often assumed that each time series consists of unobservable components (yet to be estimated): The seasonal component, the calendar component, the trend component, the business cycle component, and the residual irregular/error component.

short-run pattern (and potentially a positive trend). Examples are consumption, employment, investment, labour and capital income, sales and profits of companies, exports and imports, and production data.

Common definitions and conceptions of "business cycle" and their measurement principles of the condition of the cycle and the turning points are outlined in the following:[57]

- *Classical business cycle concept*: The percentage change of the real gross domestic product can be understood as business cycle in the classical paradigm. The term "recession" is often associated with the term "technical recession" that denotes two subsequent quarters with a decrease of the real, seasonally-adjusted GDP compared to the previous quarter.

- *Output gap (deviation from potential output)*: The notion "potential output" was advocated by OKUN [1962]. It denotes the "normal" production level that corresponds to a capacity utilization at which the input factors are neither overheated nor overcooled. The difference between potential output and the actually observed production can be understood as business cycle component (as illustrated in FIGURE 33). If the business cycle is identified by the trend deviation (output gap), then one speaks of the growth cycle concept. Several methods for the determination of the trend deviation, which usually apply the real GDP or industrial production, are explained in the appendix (2.A.1.3).

- *Multiple variables:* The business cycle can also be traced as a phenomenon that affects the whole economy and is therefore captured by many variables

[57] AMSTAD [2000] explains the different concepts of business cycle identification and applies them to the Swiss economy. Other overviews on definition, measurement and prediction of business cycles can be found in HARTWIG AND SCHIPS [2010], TICHY [1994], KNOOP [2004] and NIERHAUS AND STURM [2003].

(„Business Cycle as a Consensus“).[58] In this prospective, the individual considered variables are usually removed from their trend and possibly also from seasonal factors to extract the individual business cycle signal. Similar methods are often applied like in the determination of the output gap. The selected variables/indicators are then aggregated to a common signal, a composite indicator representing the business cycle of the whole economy. Relevant aggregation techniques will be dealt with in the appendix (2.A.1.5).

Advantages of a composite index compared to the individual indicators lie in the addition of information, the smaller volatility and the faster transmission of cyclical impulses. The aggregation to a composite indicator is supposed to generate an indicator with a smoother and more stable evolution than the individual variables which enhances the reliability. Multiple indicators with either leading or coinciding features are often gathered to a (leading or coinciding) composite indicator. Also the KOFL KonSens aims at providing a coinciding composite indicator out of individual indicators. The reason why composite indicators are often regarded as being more reliable is connected with the nature and causes of business cycles. „The performance of individual indicators […] [depends] on the causes behind a specific cycle. Some indicators will perform better in one cycle and others in a different cycle“ (NILSSON [1987, p.115]). Therefore, it is useful to collect signals for all kinds of cyclical tendencies by the consideration of plenty of various indicators. Prominent examples of coinciding composite indicators are the EuroCOIN of the Conference Board, which is used for the European business cycle detection (see ALTISSIMO ET AL. [2001]). OZYILDIRIM, SCHAITKIN AND ZARNOWITZ [2010] discuss various leading and coincident composite indicators.

[58] One could argue that the definitional frontier of distinction between the usage of one single series such as the GDP and the conception of the business cycle as an interaction of several influences/variables is fluent. Also for the computation of the GDP, on theoretical and practical grounds, a great many of different variables are included and aggregated (for example consumption, investment, wages, profits etc.).

2.3. Motivation and Goal of KOFL KonSens

The introduction of a composite indicator, as done in this project, shall expand the (in the context of Liechtenstein) scarce base of business cycle relevant quarterly indicators and gather all the different kinds of quarterly economic data to a consistent main signal for the evaluation of Liechtenstein's business cycle. The measurement of the cyclical fluctuations, free from long-term growth trend and seasonal impacts, are thereby of central importance, as it is usually the case in business cycle analysis.

The KOFL KonSens delivers clear indications about the economic climate of Liechtenstein's economy by simplifying the time-consuming study of different sources and publications to a summarizing message. This messaging signal will be supplied to the media, companies in industry and financial services, the public administration, the political decision makers and to the wider interested public. This is achieved by the quarterly publication of the KOFL KonSens by the KOFL Liechtenstein Economic Institute. The base for business cycle research in Liechtenstein will be enhanced and in this vein the better judgment of the economic situation will support the *quantitative annual forecast* of Liechtenstein's GDP, which is carried out annually in February by KOFL. The KOFL KonSens furthermore obtains a reference series that is the economic and econometric foundation for a *qualitative quarterly forecast* of the future business cycle tendency.[59]

[59] A qualitative forecast also takes the fact into account that quantitative point forecasts are often rather unreliable. Especially in Liechtenstein, a precise point forecast of GDP is difficult because of the very high volatility and the typically small number of observations of the relevant time series. Both can lead to large confidence intervals of the forecasts. Relevant information about the future economic development can also be drawn from quantitative forecasts, such as the prediction of the KOFL KonSens-value in the next quarter. The KOFL KonSens-value in fact represents a qualitative artificial conception of an aggregated output gap with relative comparability over time.

2.4. Provision of Quarterly GDP for Liechtenstein

As already mentioned, there exist no quarterly figures of Liechtenstein's GDP. Since the GDP belongs to the most important indicators, it is valuable to generate quarterly figures in an estimative temporal disaggregation model and to include them in the KOFL KonSens. Doing so, annual figures of GDP and quarterly proxies with a high correlation to GDP are necessary. Officially published annual GDP-figures along with the national accounts, which are usually published in December (Liechtensteinische Volkswirtschaftliche Gesamtrechnung, VGR FL), exist for the years 1998 to 2009. The GDP for the year 2009 was released in December 2011 by Liechtenstein's national OFFICE OF STATISTICS [2011]. Beyond that there are flash-estimates for the years 2010-2011 and a forecast for 2012 by KOFL available (for both see SCHLAG [2012]), and also retrospective estimates of the GDP for the years before 1998 that were computed earlier in this dissertation (chapter 1.4.). Though the Office of Statistics also released in February 2012 a flash-estimate for the year 2010 it makes more sense to apply the figures of KOFL, since they exist for both recent years 2010 and 2011 and it is therefore more appropriate to use figures that have been supplied by the same estimation approach in order to avoid structural breaks. The hybrid time series of GDP is displayed in nominal and real form in the chart of FIGURE 35, supplemented by the growth rates. The estimations for the years 1972-1997 and 2010-2012 are compatible with the official data as they target to be according to identities of the national accounts (VGR FL) and can be chained to a consistent time series without severe structural breaks. The different sources are marked by the dashed vertical lines.

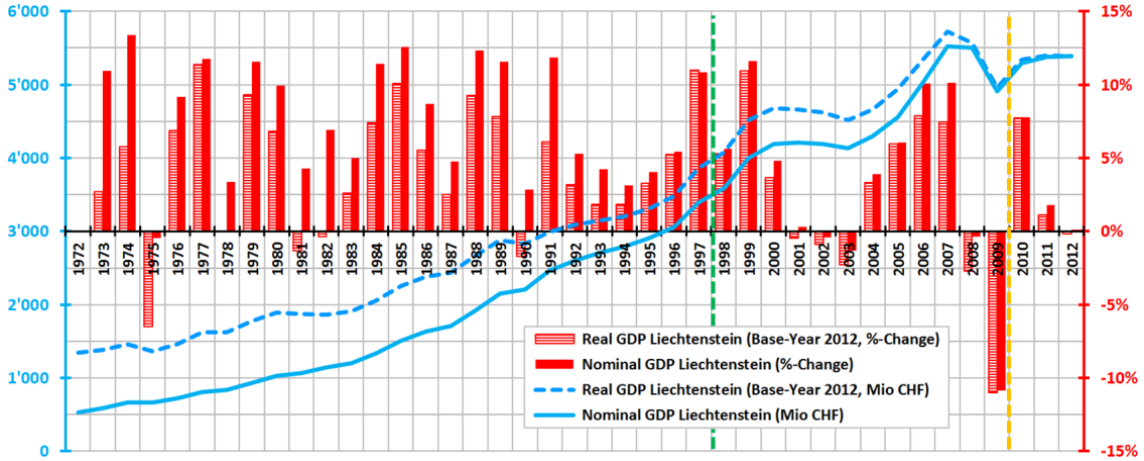

FIGURE 35: Real and nominal annual GDP (LHS) and growth rates (RHS)

Several economic series are eligible as adequate quarterly indicators. As shown later on, the strongest logical and statistical relation to the gross domestic product in the case of Liechtenstein, considering all the available economic quarterly variables, have export figures of Liechtenstein, the Swiss GDP and the (indexed) sales data of the most important corporations in Liechtenstein's sectors industry, financial services and other services. The proper definitions and explanations of the exports and the sales data is outlined in the appendix (2.A.2.).

The relevant procedures that were applied and comparatively evaluated in this project can roughly be divided into two groups:[60]

- *Methods <u>without</u> reference indicators*: „Naïve" mathematic methods such as means/aggregations or simple linear interpolations can be counted to this group. A more complex statistical approach is the one after BOOT ET AL. [1969] or the univariate variant of DENTON [1971].

- *Methods <u>with</u> reference indicators*: These procedures take advantage of proxies that correlate with the series whose frequency is being increased. Various

[60] Various procedures for temporal disaggregation (distribution and interpolation) are explained in DAGUM AND CHOLETTE [2006]. Other popular methods are the Pro-Rata method and also the methods after WEI AND STRAM [1990] or SANTOS SILVA AND CARDOSO [2001]. An approach applying the Kalman filter is outlined in NEUSSER [2009, p.252-254].

alternatives of the multiple approach by CHOW AND LIN [1971] will be applied in this chapter, as explained in more detail later on.

The chosen method group after CHOW AND LIN [1971] is based on a generalized (linear) least squares estimator. This temporal disaggregation procedure is basically carried out in three stages:

- First of all, a statistical connection between the reference series to be disaggregated (in this case the GDP) and correlated indicators is constructed by regressing the relation between the proxies and the reference series. The obtained regressive relation determines how the annual GDP is distributed to the various quarters.

- Then, the applied methods make sure that the generated quarterly figures exactly sum up to the actually observable yearly benchmark (Liechtenstein's annual GDP).

- At last, under usage of the applied regression model an extrapolation can be executed for the current year for which no annual benchmark exists yet, in order to provide „nowcasts" and confidence intervals for the recent quarters.

Now, the most appropriate indicators out of a pool of available economic data series are being identified. The selection is subject to economic considerations and in a further step the series are being evaluated by their methodological suitability and their statistical co-movement with the GDP. As noted earlier, the following proxies have been selected:

- The quarterly nominal *GDP of Switzerland*, which is accessible from the first quarter of 1965 until the first quarter of 2012 and computed and published online by the Swiss State Secretariat of Economic Affairs (SECO).

- Liechtenstein's *exports* of goods (without exports to Switzerland). These are compiled by the Swiss Federal Customs Administration (EZV) and are available from the first quarter 1995 to the first quarter of 2012.

- The indexed *total sales* of the 25 largest companies of Liechtenstein. These figures are compiled by the Liechtenstein Tax Administration and confidentially supplied to the KOFL. They are available from the first quarter of 1999 till the last quarter 2011 (see chapter 2.A.2. for further explanations).

The three considered indicators and their correlation, in levels and growth rates (versus the prior quarter), with Liechtenstein's annual GDP are displayed in TABLE 45.

Correlation (1999-2011)		GDP CH	Exports FL	Sales FL
GDP Liechtenstein	Level	0.9475	0.8558	0.8963
	Growth Rates	0.6983	0.8915	0.8093

TABLE 45: Correlation of Liechtenstein's GDP with the regarded indicators (annual figures)

The applied temporal disaggregation (distribution) method shall be presented now, on the basis of SCHWALLER AND PARNISARI [1998, p.10-15] and CHOW AND LIN [1971, p.372-374] and with slightly changed notation, also modified for the used indicators.

As a first step, the main regression equation is in focus. This regression involves the quarterly GDP-figures to be derived as a linear function of the quarterly proxies.

[1] $$GDP = \beta X + u, \qquad \text{with } X = \begin{bmatrix} EXP_1 & SALES_1 & GDPCH_1 \\ EXP_2 & SALES_2 & GDPCH_2 \\ \vdots & \vdots & \vdots \\ EXP_{4T} & SALES_{4T} & GDPCH_{4T} \end{bmatrix}$$

Matrix X features the quarterly indicators, β is the coefficient vector and u is the residual error with zero mean and the variance-covariance-matrix $V = \mathrm{E}[uu']$. $4T$ is the number of observations of the proxy indicators. T is here 13, since the years 1999 to 2011 are included. For each quarterly indicator $4 \cdot T = 52$ observations are available for the coefficient estimation, whereas one quarter of 2012 will be extrapolated. Equation [1] can now be modified such that quarterly and yearly (denoted with an asterisk) data are connected with each other:

[2] $$GDP^* = X^*\beta + u^* = C \cdot X \cdot \beta + C \cdot u = C \cdot GDP \quad \text{with}$$
$$V^* = \mathrm{E}[u^* u^{*\prime}] = CVC^{*\prime}$$

C depicts the conversion matrix with dimension $T \times 4T$ and transforms $4 \cdot T$ quarterly into T annual data. In the case of a temporal distribution (not an interpolation) of annual into quarterly figures here the conversion matrix has the following form:

$$C = \frac{1}{4}\begin{bmatrix} 1 & 1 & 1 & 1 & 0 & & & & \cdots & & & & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & & \cdots & & 0 \\ & & \vdots & & & & \ddots & & & & & & \vdots \\ & & & & & & & & & & & & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 & 1 & 1 & 1 & 1 \end{bmatrix}$$

CHOW AND LIN [1971, p.373] derived the unbiased and efficient estimator for the estimation problem above:

[3] $$G\hat{D}P = X \cdot \hat{\beta} + \left(VC'\left(V^*\right)^{-1}\right) \cdot \hat{u}^*$$

CHOW AND LIN [1971, p.374] have also shown that their advocated estimator delivers quarterly figures that satisfy the aggregation restriction, they therefore always sum up to the annual total:

[4] $$C \cdot G\hat{D}P = X^*\hat{\beta} + \hat{u}^* = GDP^*$$

Several variants of the just outlined approach are discussed in the literature. They mainly differ with respect to the assumptions regarding the variance-covariance-matrix $V = E[uu']$. While the approach of BOURNAY AND LAROQUE [1979] (equation [6]) emanates from an error u that follows a stationary (first-order) autoregressive process, the error in the contribution by FERNANDEZ [1981] describes a non-stationary autoregressive process, namely a random walk (equation [7]). LITTERMANN [1983] implies an error that is characterised by a Markov-process that represents a random walk with a separate auto-correlated but stationary error (equation [8]).

[6] $u_q = \rho \cdot u_{q-1} + \upsilon_q, \quad q = 1,...,n$ with $|\rho| < 1$ and $\upsilon_q \sim NID\left(0, \sigma_\upsilon^2\right)$

[7] $u_q = u_{q-1} + \upsilon_q, \quad q = 1,...,n$ with $\upsilon_q \sim NID\left(0, \sigma_\upsilon^2\right)$ and $u_0 = 0$

[8] $u_q = u_{q-1} + e_q$ and

$e_q = \mu \cdot e_{q-1} + \upsilon_q, \quad q = 1,...,n$ with $|\mu| < 1, \ \upsilon_q \sim NID\left(0, \sigma_\upsilon^2\right)$ and $u_0 = e_0 = 0$

Various measures, which provide insights into which variables to be included in the model and also which is the optimal specification regarding the just mentioned assumptions about the error, are being consulted in this project. The model should exhibit *uncorrelated residuals*. The test statistics of DURBIN AND WATSON [1950] is considered for this inspection. Also, *goodness-of-fit* measures as R^2 and adjusted R^2 are taken into account[61] and also the *significance* of the estimated parameters. The *information criterion* by AKAIKE [1974] plays an important role as well. The number of degrees of freedom is especially relevant in this context. It is important because of the typically low number of annual observations. The information criterion is useful in solving the following trade-off: Additional indicator variables are accompanied by a loss of degrees of freedom but can improve the model in being more stable (in terms of outliers and revisions etc.). Usually, information criteria are used for the determination of the lag order of the variables within a regression, but they are also useful for the comparison of nested and non-nested models, also evaluating the

[61] A non-satisfactory value of the Durbin-Watson statistic along with a very high R^2 would indicate "spurious regression".

entire exclusion or inclusion of variables, as long as the dependent variable remains unchanged. The also considered *reliability indicator* assesses the relative magnitude of the confidence interval and evaluates the reliability of the estimated quarters. The confidence interval is also being visually inspected.

After the temporal disaggregation, the GDP has to be extrapolated for the quarters of the yet unfinished year. DI FONZO [1987] derived the optimal prediction function for this goal applying the regressive relation between GDP and the proxies (without the aggregation constraint).

Liechtenstein's GDP is now available in a quarterly frequency, in nominal and seasonally non-adjusted terms. As explained in the appendix (2.A.1.2.), also real figures are generated here by applying the Swiss GDP deflator to Liechtenstein's quarterly GDP. The seasonal adjustment step is explained in chapter 2.5. and in the appendix (2.A.1.3.). The annual total of the seasonally-adjusted figures usually deviates a little from the annual total of the raw data, which can be disturbing but is not classified as being problematic by EUROSTAT [2009, p.19] in their guidelines of the practice of seasonal adjustment. An econometric (typically time-consuming) removal of this slight difference is not suggested. Regarding the importance of the GDP as an indicator and the probable future publication of the quarterly GDP (besides the KOFL KonSens), a so-called „benchmarking" is carried out here nonetheless. The benchmarking procedure makes sure that the annual total of the seasonally adjusted and the raw data is equal by simply applying the same temporal distribution method from equations [1] to [8]. But this time the provisional seasonally-adjusted data is being slightly revised via using them as indicators for the temporal disaggregation obtaining final seasonally-adjusted figures that fulfil the aggregation constraint (the annual total of the non-adjusted data).

FIGURE 36 summarizes the necessary steps for the estimation of quarterly figures of Liechtenstein's gross domestic product.

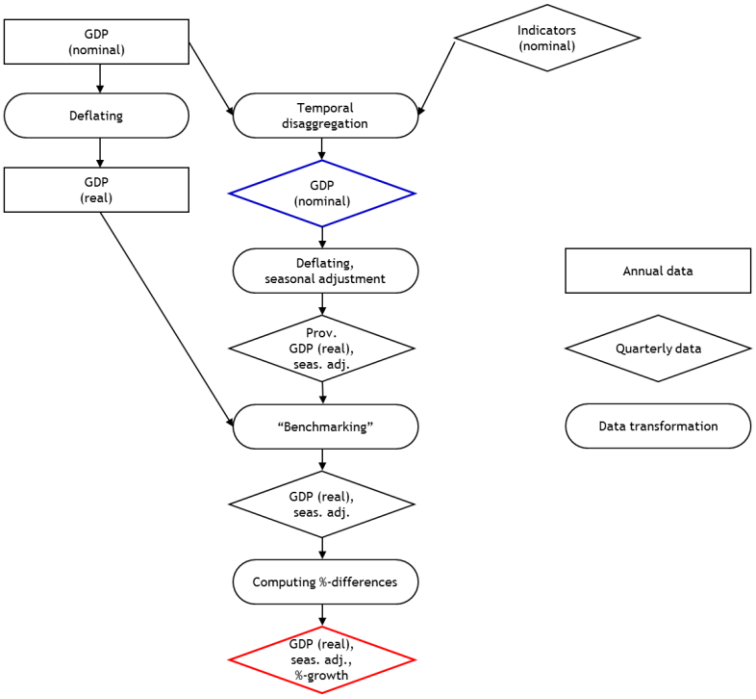

FIGURE 36: Work steps of the temporal disaggregation of Liechtenstein's GDP

Accounting for the already explained measures (goodness-of-fit, information criteria, reliability indicator, characteristics of residuals), the approach by LITTERMAN [1983] has been selected. Thereby not the variant of minimizing the sum of squares but the optimization of the log-likelihood has been chosen. The Swiss GDP has been dropped from the regression; this proceeding was supported by the mentioned measures. Thus, only the export and the sales data series are included into the temporal disaggregation model.

The quarterly sales data that the KOFL receives from the national tax administration are not published and are confidential.[62] Hence, the exact regression results cannot be displayed here, since this would enable insights into the confidential original sales data. Still, a few important conclusions can be drawn and stated: No autocorrelation of the residual can be detected by the test statistics of DURBIN AND WATSON [1950] (with significance points after SAVIN AND WHITE

[62] The sales data (divided after the three sectors „industry/production", „services" and „financial services") is in percentage changes. These growth rates are translated into indexed levels, as explained in the appendix (2.A.1.).

[1977]) and LJUNG AND BOX [1978]. The F-Test (p-value: 0.0000) indicates joint significance of the independent variables and the R^2 is satisfactory with 0.89.[63] The existence of „spurious regression" can therefore most likely be excluded (also taking the durbin-watson statistic into account).[64] It has also been tested if the aggregation constraint has really been met. Along with the introduced method, quarterly figures are accessible in nominal and real/seasonally-adjusted form. These figures are charted in FIGURE 37.

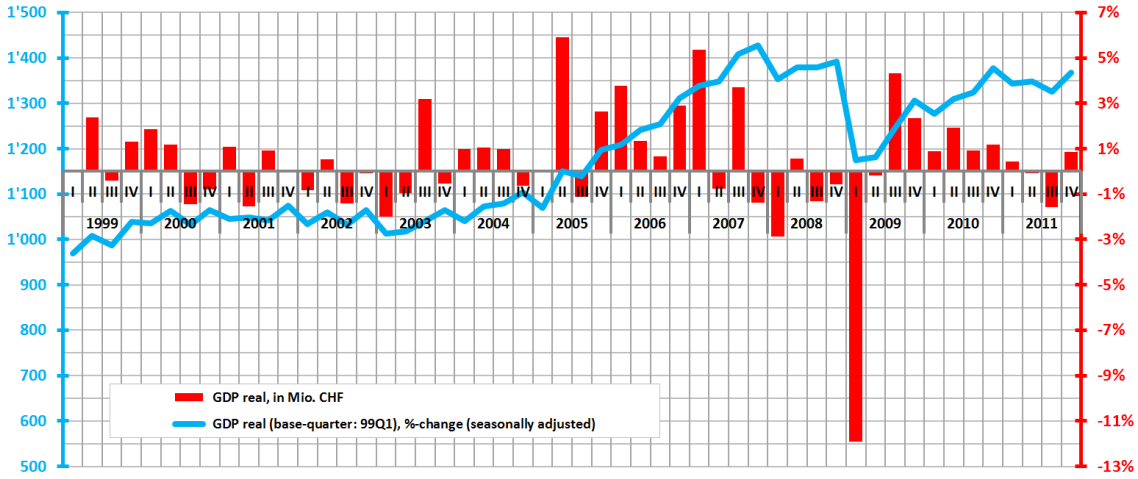

FIGURE 37: Quarterly GDP of Liechtenstein, nominal level (LHS) and real growth rates (RHS)

Striking in the graphical chart of Liechtenstein's GDP is especially the heavy breakdown in 2008/2009 as a consequence of the international financial crisis also affecting the export industry and also the disturbances in Liechtenstein's financial sector (data theft, tax affair and the big reforms impacting the financial centre as being discussed in chapter 3).

63 This goodness-of fit measure is insightful in this context, because the positive trend in the annual GDP is not persistent during the whole sample and also exhibits phases of stagnation and downturn. Thus, the high correlation is not just an artefact of the positive trend. It could theoretically be that the variables only correlate because they simply follow a random walk (with drift) without being related to each other. This does not seem to be the case here.

64 The notion „spurious regression" has been discussed by GRANGER AND NEWBOLD [1974].

The procedure of temporal disaggregation typically contains the consecutive necessity for revisions because of several reasons which are discussed later on (chapter 2.6.).

2.5. Setting and Methodology of KOFL KonSens

The main stages and work steps of the development and the actual computation of the KOFL KonSens shall now be documented and the related statistical methods be presented briefly (some of them are explained in more detail in the appendix 2.A.1.). The first results will be presented in the next chapter (2.6.).

Even though the data base of Liechtenstein's economic statistics is rather thin, especially in sub-annual frequency, there are several quarterly data series that are relevant for business cycle analysis. It makes sense to proceed systematically after certain criteria in the search of appropriate individual indicators for the KOFL KonSens:

- *Connection to Liechtenstein*: The considered indicators should all directly refer to Liechtenstein or at least have a plausible relation or an influence on Liechtenstein's economy.[65]

- *Full availability*: The time series of the relevant variables should be available for the entire regarded time span (first quarter of 1999 until fourth quarter of 2011) without data gaps.

[65] The actual causality's direction is not of central importance, only the correlation. Whether the change of a variable directly influences the business cycle (it could for example be that a higher money supply may boost investments) or is just affected by it as a consequence, is not in main focus along with the construction of a composite indicator. The division of cause and effect and their timing is a general problem in empirical economics and even with complicating models only hard to capture (increasing money supply or higher public investment could as well be political reactions on bad economic performance). Examples for a possible question in this context would be: Are rising exports of Liechtenstein a direct cause for the better economic climate in Liechtenstein or just an effect of an international boom that also affects Liechtenstein (via other channels than the trade of goods). The investigation of such issues opens a wide field of future research: For example the investigation of the synchronicity of Liechtenstein's business cycle with the neighbouring countries, the possible lead or lag of Liechtenstein's economy in the cycle, or endogeneity/exogeneity of shocks.

- *Short publication lag*: The data should not exhibit a long publication lag and therefore be available shortly after the end of the quarter in order to allow a fast computation of the KOFL KonSens and as a consequence a prompt business cycle analysis. A maximal publication lag of two months will be aimed at.

- *Small revisions*: The values of the KOFL KonSens are inevitably subject to econometrically-caused revisions, for example in the course of seasonal adjustment and trend removal. To minimize the revisions of the composite indicator it is important that the indicators are not often and not heavily revised in their original sources.

- *Consistency*: The variables should not feature strong outliers or structural breaks. Especially not if these are of methodical nature of compilation and not economically explainable.

- *Cyclical pattern*: The individual indicators should have a visible and steady evolution through the business cycle. To get a better impression, it is often advisable to already remove seasonal inference and trend (methods explained in the appendix 2.A.1.) in a provisional manner during the sighting and evaluation process.

- *Economic interpretation*: The evolution of the individual variables' cyclical component should have an economic interpretation and explanation during the whole time period.

- *Minimal dimension*: A too large number of indicators and/or too few observations can be a problem for the aggregation method. In order to minimize the number of involved variables in the principal component analysis (in appendix 2.A.1.5.) in case of several very similar variables only

one is considered. This is done to reduce the dimension of the statistical aggregation procedure (and the covariance-variance matrix).

The selected indicators, which have been chosen according to the criteria just outlined, are listed in TABLE 46. They are all available for the whole time span, beginning with the first quarter of 1999 and ending with the last quarter of 2011.

Individual Indicators	Source	Transformations	Publication Lag
Employed people	AfS	Q^-,S,T,N	2 months
Inward commuters	AfS	Q^-,S,T,N	2 months
Unemployed people [reciprocal value]	AMS	Q^-,S,T,N	0 months
Job openings [reciprocal value]	AMS	Q^-,T,N	0 months
Prices (LIK) [indexed]	BfS	Q^-,S,T,N	0 months
Gross domestic product [CHF, nominal]	KOFL	Q^+,D,S,T,N	2-6 months*
Exchange rate index [indexed]	SNB	Q^-,T,N	0 months
Exports [CHF, nominal]	EZV	D,S,T,N	1 months
Imports [CHF, nominal]	EZV	D,T,N	1 months
Newly registered cars	AfS	Q^-,S,T,N	2 months
Overnight stays	AfS	Q^-,S,T,N	3-6 months*
Consumer sentiment [indexed, average of CH and A]	Seco/EUK	Q^-,S,T,N	0 months
Overall situation (business survey) [indexed]	AfS	S,T,N	2 months
Capacity utilization (business survey) [indexed]	AfS	S,T,N	2 months
New orders (business survey) [indexed]	AfS	S,T,N	2 months
Earnings (business survey) [indexiert]	AfS	S,T,N	2 months
Sales (industry) [CHF, nominal, indexed]	StV	D,S,T,N	2-6 months*
Sales (financial services) [CHF, nominal, indexed]	StV	D,S,T,N	2-6 months*
Stock prices [CHF, nominal]	SIX	Q^-,D,T,N	0 months
Interest spread [%-points]	SNB	Q^-,T,N	0 months

AfS: Office of Statistics Liechtenstein (Amt für Statistik); BfS: Swiss Statistics (Schweizerisches Bundesamt für Statistik); SNB: Swiss National Bank (Schweizerische Nationalbank); AMS FL: Job Market Service Liechtenstein (Arbeitsmarktservice Liechtenstein); KOFL: Liechtenstein Economic Institute (Konjunkturforschungsstelle Liechtenstein); KOF: Swiss Economic Institute (Konjunkturforschungsstelle ETH Zürich); StV: Tax Administration Liechtenstein (Liechtensteinische Steuerverwaltung); EZV: Swiss Federal Customs Administration (Schweizerische Eidgenössische Zollverwaltung); EUK: European Commission (Europäische Kommission); SIX: Swiss Exchange; Seco: Swiss State Secretariat of Economic Affairs (Schweizerisches Staatssekretariat für Wirtschaft).
Q^-: generating quarterly figures (reduction of frequency); Q^+: generating quarterly figures (increase of frequency); D: Deflating (nominal to real figures); S: seasonal and calendar adjustment; T: trend removal; N: normalization.
* Faster availability in the future is very likely, but at the moment still subject to clarifications

TABLE 46: Individual indicators of composite index KOFL KonSens

Many annual and especially sub-annual economic time series in Liechtenstein do not exist before the 1990s. Almost all considered series are accessible to the public. Exceptions are the sales data from the national tax administration and the sub-annual employment data from the Office of Statistics. Even though the figures are not publically accessible they are confidentially provided to KOFL for research purposes. The quarterly GDP was derived from the annual GDP by the application

of a temporal disaggregation and extrapolation method that was carried out in the previous chapter (2.4.).

With the exception of the sales data all data is at hand until the first quarter of 2012. As they are only available until the fourth quarter of 2011 the computations have initially only been carried out until that quarter to develop, illustrate and execute the applied procedure and supply first results for the regarded time span. A faster availability of the sales data is intended in the near future. If this faster availability of the sales data cannot be reached (which is not to expect) then the KonSens might be computed in a provisional manner for the last one or two quarters (to be revised when the sales data becomes available) or the sales data is completely excluded from the KOFL KonSens.

The individual indicators from TABLE 46 are subject to data collection and transformation. The detailed statistical and mathematical procedures are illustrated in FIGURE 38 and explained in the appendix (2.A.1.) and shall be briefly mentioned here:

- *Obtaining quarterly figures*: At first, all non-quarterly data series (daily, monthly or annual) have to be transposed into quarterly frequency by temporal aggregation (sum or arithmetic mean depending on the nature of the data), interpolation or disaggregation. The later procedure was shown in chapter 2.4., where the applied variant of CHOW AND LIN [1971] was outlined.

- *Deflation*: Once the right frequency is obtained, those time series measured in monetary units have to be deflated. The Swiss Index of Consumer Prices (LIK), the Swiss export price index, and the Swiss GDP-deflator are used as deflators.

- *Seasonal and Calendar Adjustment*: Before the isolation of the intended business cycle component seasonal and calendar inference is being

eliminated. Census-X-12-ARIMA divides the time series into a seasonal and non-seasonal component. The non-seasonal component contains the business cycle component and the trend component.[66]

- *Trend removal*: For each seasonally-adjusted data series, the trend component is estimated to derive the cyclical component, applying the HP-filter of HODRICK AND PRESCOTT [1997]. The cyclical component is then simply the percentage difference of the actually observed value and the derived trend value for each observation. To increase the stability for the most recent observations (and therefore lowering the "end-point problem" explained in the appendix), the (seasonal) ARIMA-model that has already been executed for each individual series in the seasonal adjustment process is used to generate forecasts that are also involved in the filtering.

- *Normalization*: All variables are scaled to zero mean and standard deviation of 1 to reach a comparable spectrum. This features various advantages. The cyclical fluctuations are better comparable and the normalization prevents methodological concerns that arise in the principal components analysis if the relevant data series are strongly differing in their dimension, level or band-with.

Once the data has been adequately transformed, they are all compiled for the main step, the *aggregation* to the KOFL KonSens value for each quarter. This is then the combined mutual business cycle signal. The aggregation to a composite indicator is achieved by the principal components analysis after HOTELLING [1933]. During the computation process not only the value of the first principal component (which denotes the KOFL KonSens value) of the current quarter is computed and published, but also revisions of past, less recent KonSens values are carried out. These newly generated and revised values can deviate a little from the previously

[66] The non-seasonal component also exhibits the irregular term/component.

released ones. The revisions caused by the aggregation method supplement other sources of revision arising from the transformation methods explained earlier.[67]

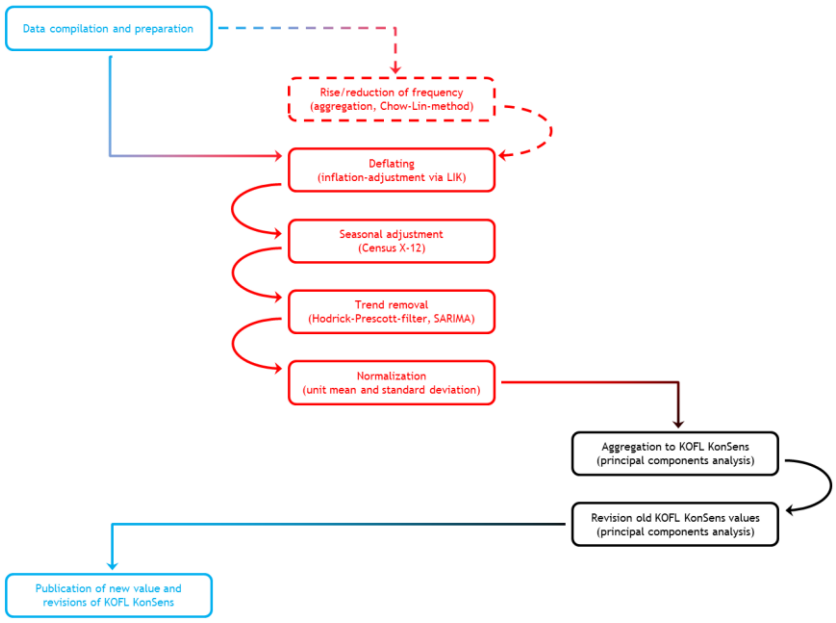

FIGURE 38: Data transformation of the individual data series and their aggregation

[67] The sensitivity to revisions, mainly for the most recent quarters, is deployed by the methods for seasonal adjustment and trend removal. Also the temporal disaggregation can lead to revisions. Also the raw data source can be subject to revisions. These reasons for revision are discussed in chapter 2.6. and in the appendix (2.A.1.).

2.6. Computation and First Results

The execution of each separate step explained in the previous chapter is not going to be illustrated here in detail. But these steps are displayed in the appendix (2.A.1.), where the GDP-series is transformed in an exemplary manner representing the transformations carried out for all individual indicators.

First results of the KOFL KonSens[68] and its evolution during the quarters of the last thirteen years are charted in FIGURE 39. An economic interpretation of the chart is given later on in this chapter. The value of the KOFL KonSens (depicted on the y-axis of FIGURE 39) is equal to the first component derived by the principal components analysis, which aggregates all considered individual indicators and which is explained in the appendix (2.A.1.5.).

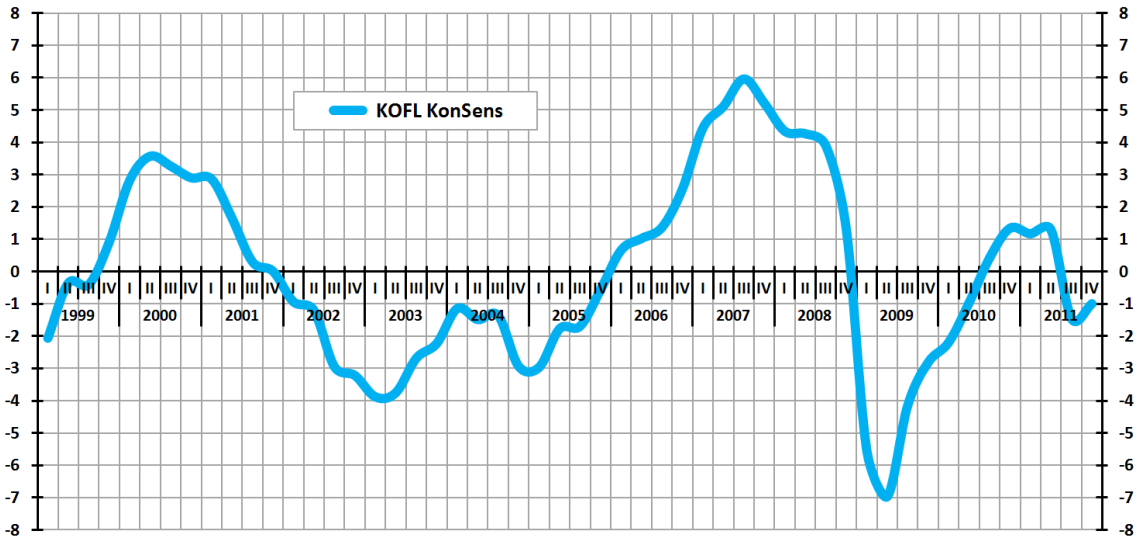

FIGURE 39: Evolution of the composite indicator KOFL KonSens over the last 13 years

Inspecting the cyclical component of various important individual indicators one can examine whether the principal component analysis captures and aggregates the fluctuations well. The optical test in FIGURE 40 is very satisfactory, if the KOFL

[68] The absolute level of the KOFL KonSens only has a qualitative interpretation, but a quantitative comparison between the different points in time is possible. Thus, the recession in 2009 (value of about -6.5) can be regarded as more severe than in 2003 (value of about -4).

KonSens is compared to the important cycles of the goods exports, the GDP, the sales of the financial sector and the stock values of Liechtenstein's quoted companies.

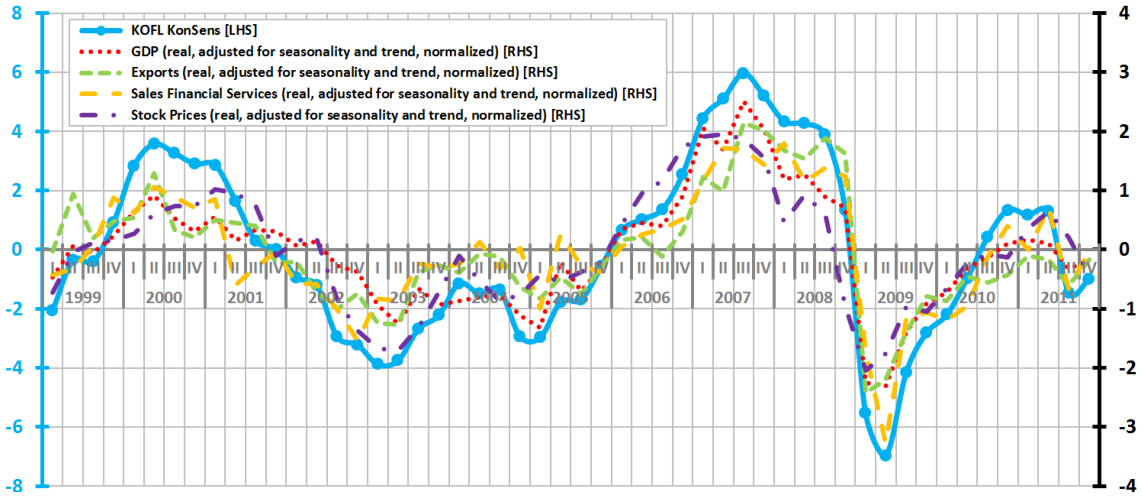

FIGURE 40: KOFL KonSens and normalized trend deviation (cycle) of chosen indicators

Empirical comparisons also show: The economic insights delivered by the KOFL KonSens are very similar to the cycle of other (international) composite indicators, such as the KOF Konjunkturbarometer for Switzerland, the Swiss GDP, the German industrial production and the total production of the OECD countries.

Apart from the already drawn conclusions concerning the comparison to the cycles of other relevant time series, one can also confirm the derived business cycle pattern of the KOFL KonSens by the historical evaluation of its economic plausibility. After the boom in 2000 and the burst of the "dot-com-bubble", a long recessive phase followed, which showed the shape of a "double-dip" recession. The gradual economic revival and the consecutive upturn peaked in the boom of 2007. By the end of 2007, the American sub-prime crisis began to be noticable. In 2008 the worldwide financial crisis (with its trough in September 2008) had a remarkably strong impact on Liechtenstein's economy, supplemented by the Zumwinkel-Affair (when a whistleblower sold data of hundreds of tax evaders). After the dramatic trough only a weak recovery took place: On the one hand, the exports were only

slowly increasing and the transformation process in Liechtenstein's financial sector was an additional challenge. On the other hand, the international debt-crisis and still existent insecurity in the economy and especially the financial markets were responsible that in 2011 Liechtenstein's economy was still far away from a boom situation, reflected very nicely by the KOFL KonSens-value that was just slightly above zero, which even led to recessive tendencies again with values below zero.

It is worth noting that, as it is usually the case in the context of business cycle research and the provision of data, a continual need to check for revisions arises for the KOFL KonSens. The reasons are manifold (additional explanations regarding the methods and their potential revisions can be found in the appendix 2.A.1):

- *External revisions of raw data*: The individual indicators may be subject to revisions by the issuers or institutions. Or they might be estimated by the KOFL, because they exceptionally are not available yet for the relevant quarter. These preliminary values are being replaced later on.

- *Estimation of quarterly GDP*: There are different causes for revisions. Firstly, the extrapolated values for the quarters of the current year (where no benchmark value for the temporal disaggregation method is available yet) are continually updated by the values of the full regressive temporal disaggregation method later on when the annual GDP becomes available. Secondly, the two recent annual observations of Liechtenstein's GDP are only flash-estimates by KOFL, which can deviate from the definitive official figures. This is due to the fact that the official national accounts feature a publication lag of almost two years. Thirdly, the estimated parameters in the course of the temporal disaggregation may vary if new annual GDP data enters the sample. This has also an impact on the computed past quarterly figures of GDP.

- *Seasonal adjustment*: The underlying regression models of the seasonal adjustment method Census X-12 are re-estimated in each quarter. This can affect the seasonally-adjusted data. Also the asymmetric features of the applied filters can make revisions necessary; forecasts via the applied ARMA-models can reduce this problem.

- *Trend removal*: The applied procedure for the trend removal (HP-filter) also implies later revisions. Here also ARMA-predictions are applied to reduce the problem of the filter asymmetry, as it has already been done in the seasonal adjustment.

- *Normalization*: The scaling of the data to zero mean and standard deviation of 1 will also influence the observations that were scaled in earlier quarters. They are potentially rescaled especially when the freshly available data exhibits extreme values. The magnitude of the revisions is rather small and decreases with rising sample size.

Generally spoken, the revision requirement is a priori assumed to be not severe. It will mainly affect the most recent figures and will diminish with a rising observation sample. The revisions of individual indicators, as just outlined, will also have an effect on the aggregated values of the KOFL KonSens. This effect will be evaluated in the future.

2.7. Conclusions

The base of business cycle analysis and prediction in Liechtenstein, especially in sub-annual context, has been supplemented in this contribution by an important tool: The KOFL KonSens that aggregates important individual indicators to a consensual, consistent main signal indicating the business cycle of Liechtenstein's economy ("business cycle as a consensus"). The individual business cycle indicators have been selected from a pool of variables before they have been time-serially transformed and aggregated. These steps and the applied methods are extensively discussed in chapter 2.5. and in the appendix (2.A.1.).

The composite indicator is not only a progress regarding the direct economic insights but also represents the basis and the reference series for the (qualitative) quarterly forecast that will complement the annual (quantitative) prediction already carried out by the Liechtenstein Economic Institute (Konjunkturforschungsstelle Liechtenstein, KOFL). The KOFL KonSens is able to capture and display the business cyclical fluctuations well and its evolution in the sample 1999 until 2012 is very plausible by economic reasoning when it is compared to the cyclical components of other national and international variables.

Among the presented and applied methods a procedure for the generation of quarterly figures of Liechtenstein's GDP has been introduced in the course of the KOFL KonSens. Such quarterly GDP data series are available for the first time and represent a useful extension of the quarterly economic data base of Liechtenstein.

In a next step, building on the introduction of the new composite coincident indicator, an econometric prediction model with the KOFL KonSens as reference series to be forecasted is planned to be developed.

Also, quicker accessibility of the important (confidential) sales data by the tax administration is aimed at and very likely. In an additional step, a so called "business cycle clock" could be introduced for Liechtenstein's economy, as it is done by Eurostat for each member of the European Union. It consists of a two-dimensional coordinate system (ordinate: cyclical deviation from trend; abscissa: growth rates) charting all the relevant individual business cycle indicators. These yield signalling business cycle clusters (see VAN RUHT, SCHOUTEN AND WEKKER [2005] for details). But as long as some of the included variables are supplied on a confidential base, these procedures are only applicable to a limited extent. Also similar displaying methods such as the „business cycle monitor" could be of further interest (for details see: OLTMANNS [2009] and ABBERGER AND NIERHAUS [2010]).

In a further analytical step, it would also be interesting to compare the identified quarterly business cycle of Liechtenstein's economy with its neighbouring countries. Either with already existing coinciding composite indices or with the generation of new indices for other countries than Liechtenstein by applying the same variables and procedures used for the KOFL KonSens.

2.A. Appendix

The methods that are applied along with the development and computation of the KOFL KonSens shall be discussed in further detail now. Appendix 2.A.1 deals with calculations, estimations and transformations, whereas appendix 2.A.2. contains the definition and description of the individual indictors that are included in the composite indicator. Practice-oriented overviews on several methods outlined in this appendix are given in BLOEM, A. M., DIPPELSMAN, R. J. AND N. Ø. MÆHLE [2001], OECD [2008], THE CONFERENCE BOARD [2001], EUROPEAN COMMISSION [1999, 2003] and of course in the cited sources respective to each method.

2.A.1. Transformations of Time Series

In the following all the applied data transformations are explained: The raw data series are being transposed into a comparable form before they are aggregated to the composite index by executing the principal components analysis: They should be in real terms, in quarterly frequency, seasonally adjusted, their long-run trend should be removed and all the variables have to be normalized. FIGURE 38 displays all the necessary steps. As an example in this appendix all the different methods are applied using the indicator GDP in an illustrating manner.

2.A.1.1. Obtaining Quarterly Figures

Those data series that are in monthly frequency have to be timely aggregated to quarterly data, either by the cumulated sum or the arithmetic average, depending on their nature (flow or stock variables). All the included raw indicators are in monthly or quarterly form, except for Liechtenstein's GDP, which is available in annual form and is being temporarily disaggregated (as shown in chapter 2.4.).

2.A.1.2. Deflating

All included variables that are measured in monetary units (here Swiss Francs) are being deflated. Unfortunately, no official deflator for Liechtenstein's economy is available. Yet, it makes sense to apply the Swiss Consumer Price Index (Landesindex für Konsumentenpreise, LIK) or other Swiss deflators because Liechtenstein participates in an economic area, a customs treaty and a monetary union with Switzerland. This deflation approach is also advocated by KOFL (see SCHLAG [2012, p.44]) and by OEHRY [2000, p.345] in his standard book about Liechtenstein's official national accounts. Official national account figures such as GDP are only released in nominal annual form. Liechtenstein's quarterly GDP, which was estimated in this project, also has to be deflated, which is done applying the Swiss GDP-deflator. All the other indicators measured in monetary units are being deflated by the Swiss Consumer Price Index before they enter the KOFL KonSens. The only exceptions are the goods exports and imports, which are deflated using Swiss import and export deflators. These Swiss deflators are provided by the Swiss Statistical Office (Bundesamt für Statistik, BfS) and the Swiss State Secretariat of Economic Affairs (Staatssekretariat für Wirtschaft, SECO).

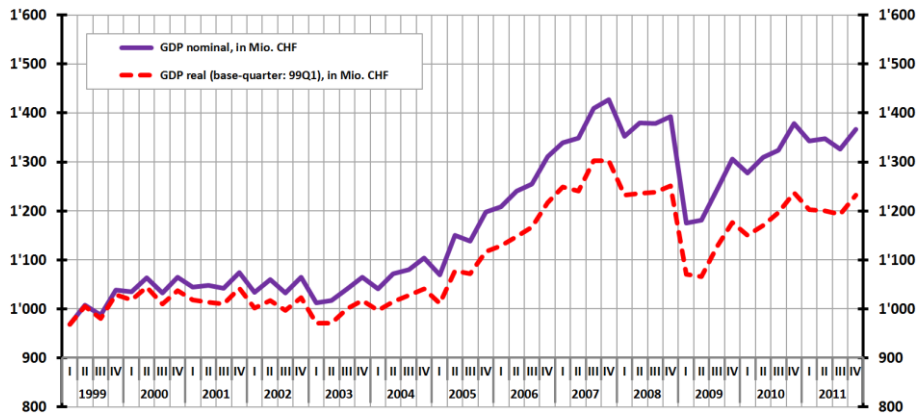

FIGURE 41: Deflating of Liechtenstein's quarterly GDP

FIGURE 41 shows the quarterly GDP in seasonally-adjusted (real and nominal) form. The GDP shall serve as a visual example for the applied data transformation of the variables. The base quarter for the deflation is the first quarter of 1999.

2.A.1.3. Seasonal and Calendar Adjustment and Trend Removal

Time series play a major role in business cycle research. This chapter shall focus on widely applied methods of time series analysis, namely concerning the trend estimation and the seasonal adjustment.[69]

One conception to look at a time series is such that a time series can be decomposed into different unobserved components; the trend g_t, the business cycle c_t, the seasonal component s_t, the calendar component k_t and the irregular component ε_t:

[9] $$x_t = g_t + c_t + s_t + k_t + \varepsilon_t$$

The trend component represents the long-term growth trend, while the cyclical component can be understood as the deviation from the long-term trend (the business cycle) induced for example by aggregated demand or monetary shocks but also fiscal or monetary interventions and stimuli. The seasonal component accounts for the fact that some time series are subject to seasonal fluctuations. For example, unemployment is usually higher in winter due to the cold temperatures, while sales or consumption tend to be higher before Christmas. The calendar component captures different amounts of holidays or working days in the different observation periods. The remainder, the irregular component, incorporates all remaining influences on the time series and outliers (for example strikes or natural disasters).

After adjusting for seasonal and calendar effects one obtains the time series y_t:

[10] $$y_t = x_t - k_t - s_t = g_t + c_t + \varepsilon_t$$

It remains now to the task to separate the trend g_t and the business cycle c_t. The two previous steps can be done applying seasonal adjustment procedures and trend

[69] Some parts of this chapter 2.A.1.3. follow BRUNHART [2006].

filters. Both will be explained later on. FIGURE 42 documents the decomposition of the unobserved components. The applied procedure there was the Census-X-12, which estimates the seasonal (denoted as "Saisonkomponente") and the calendar component ("Kalenderkomponente"), but also the trend-cycle (trend and cycle combined: "Trend-Konjunktur-Komponente") and the irregular component ("irreguläre Komponente"). The relevant series for business cycle research is now the trend-cycle-component, which would then be subject to trend removal. Note that the assumed model in this example (production in manufacturing in Germany 1995 until 1999) implies a multiplicative relation of the individual components. The difference of additive and multiplicative frameworks will be dealt with later.

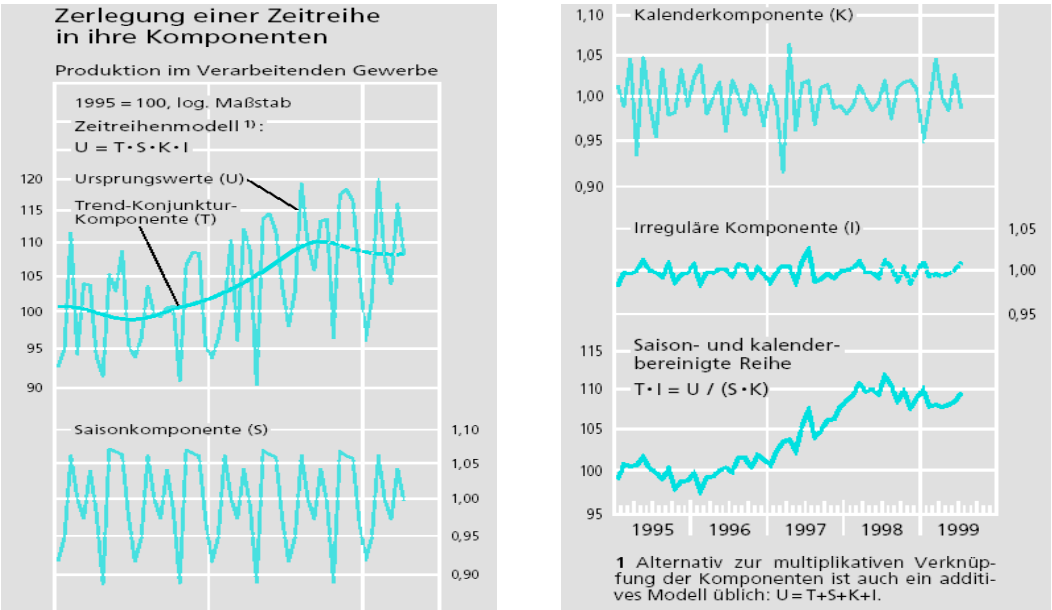

FIGURE 42: Decomposition of unobserved components of a time series
(Source: DEUTSCHE BUNDESBANK [1999, p.41])

In the course of the seasonal adjustment (and calendar adjustment), s_t and k_t are targeted to be identified and isolated in equation [9]. The most popular methods are Census-X-12, Tramo/Seats or BV4.1 („Berliner Verfahren").[70] KOFL uses Census-X-12 throughout the different applications. Census-X-12 is being applied also in this project.

[70] The method „Tramo/Seats" is summarized in MARAVALL [2005] and GÓMEZ AND MARAVALL [1996]. The „Berliner Verfahren" is discussed in SPETH [2004].

The U.S. Census Bureau has been pioneering in the field of time series with seasonal inference and presented the first computer program for seasonal adjustment in 1954. It has been continuously modified and led to Census X-11 that was widely used (see SHISKIN ET AL. [1967,p.1-2]) and was followed by the later versions Census X-11-ARIMA and Census X-12-ARIMA that all include X-11 as main component. Census-X-11-ARIMA differs from Census-X-11 in the new possibility of ARIMA-modelling options to prolong the included time series. The step from X-11 to X-12 was bigger (X-11-ARIMA to X-12-ARIMA respectively). The Census-X-12-ARIMA is new with respect to the method itself and the characteristics of the seasonally adjusted data if compared to the preceding X-11-ARIMA (see FINDLEY ET AL. [1998], p.1). It includes alternative adjustment possibilities for the seasonal and calendar effects, supplemented by built-in user options. New diagnostics evaluate the stability and quality of the seasonal adjustment procedure and the generated data and there are extended modelling options for the incorporated ARIMA-models[71] with additional estimation options for the estimation of the model parameters. In most cases the change from X-11 to X-12 did not lead to far-reaching revisions (see DEUTSCHE BUNDESBANK [1999, p.50]). Census-X-12-ARIMA consists of three main parts, as seen in FIGURE 43.

[71] An ARMA(p,q)-process (Autoregressive-Moving-Average) in the tradition of BOX AND JENKINS [1979] combines an autoregressive AR(p)-process ($\alpha_1 y_{t-1} + \ldots + \alpha_p y_{t-p}$) and a MA(q)-process (moving average of the error terms: $\varepsilon_t + \beta_1 \varepsilon_{t-1} + \ldots + \beta_q \varepsilon_{t-q}$). Hence: $y_t = c + \alpha_1 y_{t-1} + \ldots + \alpha_p y_{t-p} + \varepsilon_t + \beta_1 \varepsilon_{t-1} + \ldots + \beta_q \varepsilon_{t-q}$. Thereby, c is the optional constant of the regression, the alphas and betas are the coefficients and eta denotes the error term. Generalizing the ARMA-processes and also allowing non-stationary time series, one obtains ARIMA(p,d,q)-processes (Autoregressive-Integrated-Moving-Average) of the integration order *d*. This means that one can receive a stationary series by taking differences *d* times. More on this topic can be examined in most time series analysis books, for example in ASTERIOU AND HALL [2011], BROCKWELL AND DAVIS [2002] or NEUSSER [2009].

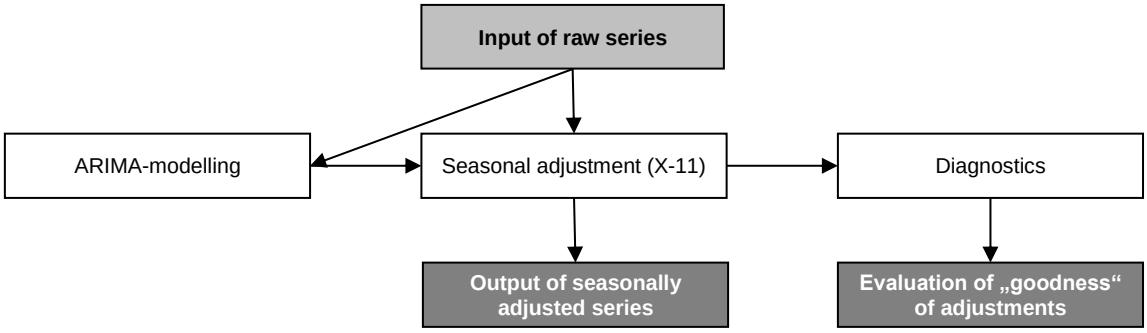

FIGURE 43: Sequence of the seasonal adjustment procedure Census X-12-ARIMA

The first part of Census X-12-ARIMA contains the optional ARIMA-modelling, which was not included in the first version of Census (X-11). This step identifies special patterns in the series and adjusts for them, which is useful for the main seasonal adjustment step (the X-11-part). The calendar components are detected and estimated and outliers are identified. The ARIMA-modelling also achieves a smaller sensitivity to revisions within the seasonally adjusted series by executing forecasts and backcasts to extend the raw series before the seasonal adjustment process (easing the problem of the non-symmetry of the Henderson-filters in the main adjustment-part).[72]

The second part, the main part of X-12-ARIMA, includes the seasonal adjustment step (low-pass filter after HENDERSON [1916]). This part coincides with the original X-11 version with a few minor modifications. The seasonal adjustment is based on the iterative application of moving averages. A multiplicative or additive version can be chosen in the X-11-part. The additive variant implies that the sum of the trend-cycle-component t_t ($t_t = g_t + c_t$), seasonal component s_t, the calendar component k_t and the irregular component ε_t will equal the total value of the raw series. The multiplicative variant assumes that the raw series is the product of the components.

Additive variant[73]: $x_t = t_t + s_t + \varepsilon_t$

Multiplicative variant: $x_t = t_t \cdot s_t \cdot \varepsilon_t$

[72] The problem of asymmetry of filters will be mentioned later in this chapter when the trend removal via HP-filter will be discussed.

[73] The calendar component k_t has been dropped here.

The additive variant represents the perception that the absolute magnitude of the seasonal deviations and the irregular inference are independent on the level of the trend component. The multiplicative alternative assumes that there is a dependency, indeed. In X-11-ARIMA and X-12-ARIMA there exists also the possibility to assume a log-additive or pseudo-additive setting.[74]

The executed moving averages are of the following form (see FINDLEY ET AL. [1998, p.8]):

[11] $$S_t^{3\times(2n+1)} = \frac{1}{3}\left(S_{t-12}^{2n+1} + S_t^{2n+1} + S_{t+12}^{2n+1}\right), \text{ whereas } S_t^{2n+1} = \frac{1}{2n+1}\sum_{j=-n}^{n} SI_{t+12j}$$

$S_t^{3\times(2n+1)}$ is a $3\times(2n+1)$ seasonal moving average. The number of observations is n and I represents the irregular component. The X-11 carries out 3×3- and 3×5-averages, but there are other selectable variants in newer versions. The SI-component (combination of seasonal and irregular part) in the multiplicative setting is $= x_t / t_t$, in the additive $= x_t - t_t$.[75] As already stated, Henderson-filters are applied for the determination of the trend-cycle component:

[12] $$T_t = \sum_{j=-H}^{H} h_j^{(2H+1)} A_{t+j}, \text{ whereas } \quad A_t = \frac{x_t}{s_t} \quad \text{or} \quad A_t = x_t - s_t$$

In equation [12] the $h_j^{(2H+1)}$ are the $(2H+1)$-Henderson-weights, whereas $-H \le j \le H$ and $h_j = h_{-j}$ apply.

In general, the computations of X-11 can be summarized as: The preliminary computations with the generation of the raw seasonal component, the determination of the final seasonal component, the final Henderson-filtering, and the definitive identification of the irregular component.

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74 Explanation about log-additive and pseudo-additive variants: see FINDLEY ET AL. [1998, p.7].

75 The original notation from FINDLEY ET AL. [1998] has been slightly changed here.

The time serial estimation models and their parameters are newly estimated for each time period, in this case here for each quarter. This may lead to minor revisions for the adjusted data of previous quarters. Also, the asymmetry of the applied filters at the end of the sample can cause revisions. That is why predictions by the ARIMA-models are included in the filtering. The sensitivity to revisions is a major concern in the search for the optimal specifications of the whole seasonal adjustment procedure along with the KOFL KonSens project.

Census-X-12-ARIMA includes several possibilities for evaluation and diagnostics that deliver insights and (if necessary) warning signs about the adjustment quality and can also provide fruitful indications for better specifications. Beyond the diagnostics of the Census-program, which is implemented in most of the popular statistical/econometrical software products, the special seasonal adjustment software Demetra+ enables additional visual evaluation possibilities, statistical tests and control values assessing the quality of the chosen adjustment setting.[76] EUROSTAT [2009], the statistical department of the European Union, released an extensive manual about the general proceeding in the seasonal adjustment. This manual should serve as standardizing guidelines for national and other official statistical departments. These principles are also maintained along with the KOFL KonSens as far as possible.

The settings are chosen as follows: It is tested whether the data should be applied in logarithms or not. Additionally, it is being tested if calendar adjustment options should be executed, such as leap-year effect, different number of workdays or Easter effect. Also, it is being inspected and tested if adjustments for outliers or structural breaks are fruitful. Then, the optimal seasonal ARIMA-Model (SARIMA) is identified and estimated, which is being determined using different measures, for example information criteria.

[76] The software Demetra+ was developed by Eurostat and can be downloaded for free at: http://circa.europa.eu/irc/dsis/eurosam/info/data/demetra.htm. More explanations can be found in the user manual of Demetra+ (GRUDKOWSKA [2011]).

Time series that are already accessible for the years before the first quarter of 1999, when the KOFL KonSens's sample starts, are applied in their full length for the seasonal adjustment to obtain a better capture of the seasonal structure behind the data. All involved series are subject to diagnostic checks: Several tests[77] examine if there exists a *seasonal pattern in the raw series* and in a next step whether there is a *remaining seasonality in the adjusted data*. Then, so-called *sliding spans* are inspected. They examine how much the seasonally adjusted data series is altered by shifting the applied time frames (partial periods of the whole sample). The *revision history* of the adjusted data over time plays a very important role as well. To evaluate the revision history the average revisions and the most extreme necessary revisions are captured and evaluated for each quarter (1999Q1 until 2011Q4). The *residuals* of the applied ARIMA-models are also screened. TABLE 46 lists which indicators have been adjusted.[78]

Also for the seasonal adjustment process real GDP shall serve as a showcase for the transformations that are applied to the indicators. FIGURE 44 charts the raw series and the adjusted series along with their growth rates.

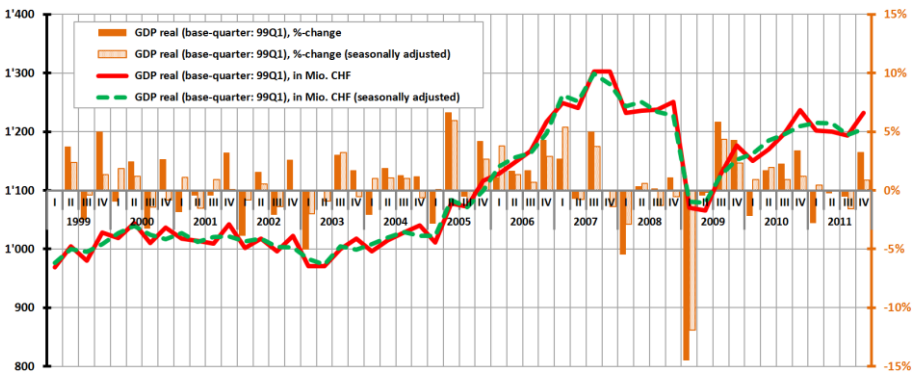

FIGURE 44: Seasonal adjustment of real GDP (LHS) and growth rates (RHS)

77 These tests are explained in GRUDKOWSKA [2011, p.191-206] and LADIRAY AND QUENNEVILLE [1999].

78 The already mentioned so-called benchmarking-problem (see chapter 2.4.) is neglected for all variables except for real GDP. Neglecting the benchmarking-problem is in line with the guidelines by EUROSTAT [2009, p.19] and presumably reduces future revisions. However, it will be checked continuously whether the differences between the annual total of the raw series and the annual total of the seasonally adjusted series remains small for each variable.

As already written in the main part of this second chapter of the dissertation, it is fruitful in business cycle research to remove the trend from the (now seasonally adjusted) data in order to locate the cyclical component. The possibilities and approaches in theory and practice for the separation of the business cycle are manifold. The most important families of methods for the estimation of the trend are:

- *Growth rates for trend removal*: The calculation of growth rates (annual or quarterly percentage change) of the time series, typically in seasonally adjusted real terms, remove the usually positive growth trend. This approach belongs to the classical concept of understanding business cycles.

- *Structural, econometric estimation of potential output*: A more sophisticated approach for the trend component is to estimate the „normal" average capacity utilization directly and not just via the statistical smoothing of a time series (in most cases real GDP), which aims at making the unobservable trend indirectly observable. There are several methods for the econometric estimation for the determination of the potential output. The regression model thereby usually incorporates theoretically based production functions (for example Cobb-Douglas or CES). The parameters of the model are then estimated or some are adapted from other calibrations. These models involve additional data for example from company surveys, official statistics or national accounts. Especially data considering the capital stock are very complicated to gather and often only accessible to a limited extent. Especially in the context of Liechtenstein this direct approach via a national production function is not possible due to the lack of relevant data.

- *Non-structural time serial determination of potential output:* It is also possible to approximate the trend component by regressing the time series on regressors that control for growth over time (possibly along with other explaining

variables). Apart from traditional deterministic trend models (trend for example as linear or exponential function of time), stochastic trends are widely applied following the "unobserved components"-approach in the tradition of HARVEY AND JAEGER [1993]. The time series decomposition after BEVERIDGE AND NELSON [1981] also belongs to this group and decomposes the non-stationary time-series into a transitory and permanent component. To be more precise: Into a deterministic (trend plus stationary component) and stochastic part.

- *Filtering for the identification of the potential output*: Filters are non-parametric methods. The filter of HODRICK AND PRESCOTT [1997], also called HP-filter, is presumably the best-known filter method. It eliminates low-frequency cycles and determines a smooth, non-linear trend.[79] Further popular methods are for example the filter of BAXTER AND KING [1981] and its modification by CHRISTIANO AND FITZGERALD [1999]. The advantage of filter techniques is harboured in the fact that they are easily applicable to any kind of economic data, not only GDP.

- *Iterative methods for the trend approximation*: A prominent example of an iterative method in this context is the „Phase Average Trend" (PAT). It has been elaborated and advocated by the National Bureau of Economic Research (NBER) and is still being applied. This iterative proceeding is based on an algorithm for the timing of business cycle turning points proposed by BRY AND BOSCHAN [1971].

[79] An exemplary and related application of the Hodrick-Prescott filter is given in BRUNHART, KELLERMANN AND SCHLAG [2012]. They apply the HP-filter to the GDP of Liechtenstein and other time series and interpret the smoothed component as national potential output und analyse the growth of it.

The detection of the business cycle via growth rates is denoted as *classical cycle*, the other mentioned procedures deliver a business cycle which is called *growth cycle*.[80] In the following, the explanatory focus shall be on the method which is executed for the determination of the individual indicators' cyclical component, the before mentioned HP-filter in its univariate variant. This filter is a symmetric filter, which means that it regards in the smoothing process the same amount of information (the same number of observations) that lie before and after the point to be smoothed. It is a modified special case of an unobserved components model.[81] The HP-filter is in practice well known relatively easy employable and generates a continuously smooth swinging curve (see STAMFORT [2005, p.19 and 112]).

Once the time series is cleaned from seasonality (and calendar effects) and trend, then the time series y_t consists of the sum of the growth trend and the business cycle (see HODRICK UND PRESCOTT [1997, p.3]):

[13] $$y_t = g_t + c_t \quad \text{for} \quad t = 1,\ldots,T.$$

The cyclical component c_t can therefore be understood as the business cyclical deviation from the long-run growth path (g_t), while it is assumed that the expected value of the cycle is close to zero considering the whole sample. The trend g_t is now derived by the following minimization:

[14] $$\min_{\{g_t\}_{t=-1}^{T}} \left\{ \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2 \right\} \qquad \text{whereby } c_t = y_t - g_t$$

The goodness-of-fit should be as high as possible. This is the case if $\sum_{t=1}^{T} c_t^2$ (sum of squared deviations of trend g_t from y_t) is as small as possible. The second part

[80] The different conceptions of the business cycle have already appeared in chapter 2.2. of this dissertation. More on the measurement techniques of the business cycle, as explained in the previous three pages, can be found in WEYERSTRASS [2001], EUROPEAN COMMUNITIES [2003], STAMFORT [2005] and RUDOLF AND ZURLINDEN [2011].

[81] For this reasoning see STAMFORT [2005, p.17-18] and WEYERSTRASS [2001, p.13-14].

of the term in brackets describes the smoothness of the trend. The minimization problem illustrates the trade-off that exists: On the one hand, one seeks to achieve a maximal goodness-of-fit of the trend curve to the original series, on the other hand a high smoothness is desired. This trade-off is formalized in λ, which is a selectable smoothing parameter ($\lambda \geq 0$, smoothness rises with higher λ) and weighs the variation of the trend component versus the goodness-of-fit (see STAMFORT [2005, p.18 and 24]). For λ being sufficiently large, the difference $g_{t+1} - g_t$ approaches the constant β. This is how an optimum is reached (see HODRICK AND PRESCOTT [1997, p.3]):

[15] $$g_t = g_0 + \beta \cdot t$$ (linear trend model[82])

Hodrick and Prescott suggest for quarterly data λ = 1‘600, for monthly data λ = 14‘000 and for annual data λ = 100.

The stability at the end of the sample is a highly discussed topic in the context of filtering/smoothing methods. As explained earlier, filter techniques are asymmetric at the beginning and the end of the sample, which may lead to revisions in a later period. An extreme example for the asymmetry is the last observation of the sample, namely the de-trended value of the last quarter, where only past observations can be considered for the smoothing procedure since no future observation are available (obviously). The reduction of the problem of asymmetry and a better stability at the end of the sample is targeted by adding predictions to each indicator series. This is done via a prediction of four quarters by the same ARIMA-modelling that has already been presented in the seasonal adjustment procedure. Also the non-seasonal series are predicted in this manner.

[82] If $\lambda = 0$, then the solution of the minimization problem is $y_t = g_t$, which is a perfect match of the trend and the raw series (see STAMFORT [2005, p.25]).

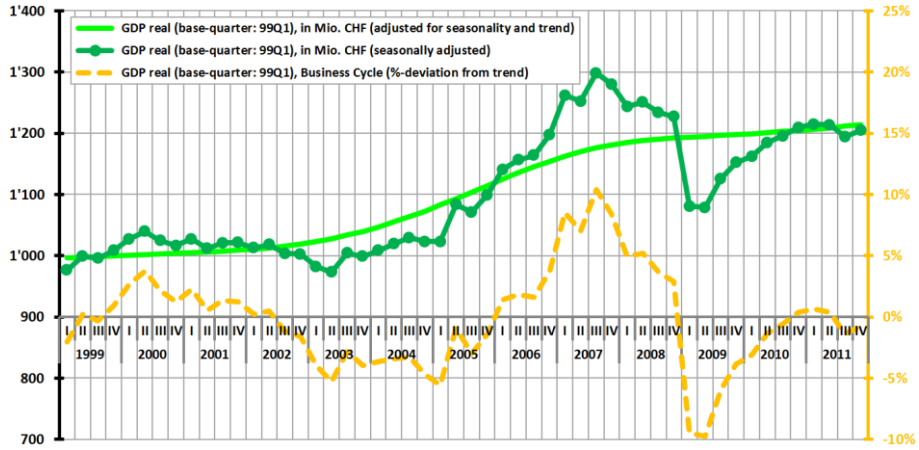

FIGURE 45: HP-trend of seasonally adjusted real GDP (LHS) and business cycle (RHS)

For all the accounted indicators the cyclical deviation from the trend is computed in percentage differences before they are normalized in the next step. Those variables that can also feature negative values in their levels, such as for example the results from the business survey or the consumer sentiment, are being modified. These variables originally span from minus 100 to plus 100. After the computation of the absolute deviation of the series from the trend 100 is added to the absolute deviation to avoid negative values which can be a problem in the calculation of the percentage trend deviation. The absolute trend deviation now lies between 0 and 200 and can then be used for the calculation of the percentage deviation from trend. FIGURE 45 shows the cyclical component of Liechtenstein's GDP, derived by calculating the percentage deviation from the long-term trend obtained from the HP-filter.

2.A.1.4. Normalization

The transformed data series will now be normalized. This means that they are scaled in such a way that they exhibit a mean of 0 and a standard deviation of 1. So, first there is an additive mean calibration and then the time series is gauged in a multiplicative adjustment to unit variance. Graphically speaking, the time series are subject to an additive shift and a multiplicative compression or stretching. The normalization has various advantages: The business cycle fluctuations are better comparable between the different indicators. The normalization also prevents statistical-methodological problems that can appear in the aggregation method (principal components analysis) if the data series are heavily diverging with respect to dimension, level or band-with.

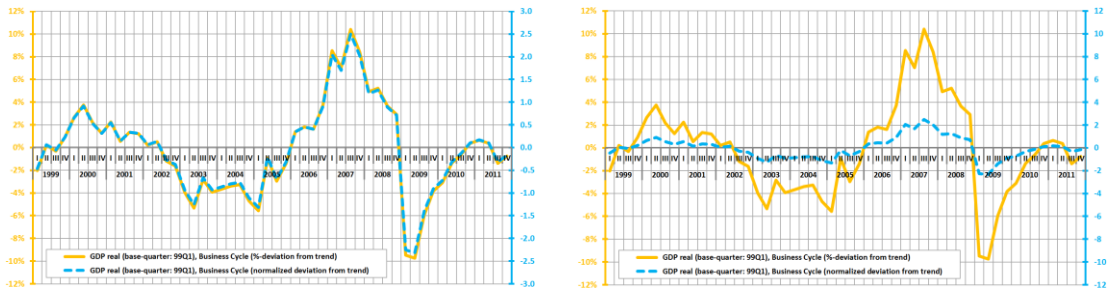

FIGURE 46: Normalization of the business cycle (LHS) to the finally transformed series (RHS)

One can observe an identical relative evolution of the non-normalized (raw %-deviation from trend) and the normalized series, as to be seen in FIGURE 46 that shows the non-normalized and the normalized series for different scaling of the axis of the normalized series in order to demonstrate the compression. In the case of the GDP a compression takes place. There are as well some indicators within the KOFL KonSens which are stretched in the normalization process.

2.A.1.5. Aggregation

An important strategy for the aggregation of the considered indicators is the principal component analysis. This mathematic-statistical method is based on contributions by PEARSON [1901] and HOTELLING [1933] and is a procedure that investigates the interrelations of different variables and their common components. The principal components are derived and ordered in accordance to their importance: The first one is the most important as it involves the greatest share of the total variance. Naïvely spoken, these principal components can be understood as a synthetic factor that lies behind the pool of data and replaces them. They are linear combinations of the original variable values and are constructed in such a way that as much of the variance as possible is explained by as few principal components as possible. Or to put it differently: Few principal components should be attributable to a big portion of the variation of the data. Hence, the number of statistical factors is being reduced without loss of important information and signals.

Following the explanations of HÄRDLE AND SIMAR [2007, p.215-225] the computational logic behind the principal components analysis shall be summarized. There are countless ways to reduce the dimension of a bulk of data. One strategy could be just to pick certain elements; this would potentially lead to a loss of information. Or one could just weigh all the variables equally. This may result in an under-evaluation or over-evaluation of the relevance of certain variables. A more expedient and sophisticated method is to weigh the elements differently. In this case here this would be the weighted average of the different business cycle indicators (see HÄRDLE AND SIMAR [2007, p.216]):

[16] $$\delta^T X = \sum_{j=1}^{p} \delta_j X_j$$

The vector $\delta = (\delta_1, \delta_2, ..., \delta_j, ..., \delta_p)^T$ denotes the weights of the variables that are included in the vector $X = (X_1, X_2, ..., X_j, ..., X_p)^T$. Usually, it is assumed that the

individual squared weights of δ sum up to 1. Equation [16] represents the linear combinations of the elements (indicators). The ways of weighting are manifold. In line with our goal, the principal component analysis chooses the vector δ in such a way that the variance of the projection $\delta^T X$ is maximized, subject to the side condition that the weights sum up to 1. The maximization problem can be expressed as follows:

[17] $$\max_{\{\delta:\|\delta\|=1\}} Var\left(\delta^T X\right) = \max_{\{\delta:\|\delta\|=1\}} \delta^T Var(X)\delta$$

The exact characterization of the weighting vectors δ is achieved by a spectral decomposition. It can be shown that δ is given by the eigenvector γ_1, which is attributed to the greatest eigenvalue λ_1 of the covariance matrix $\Sigma = Var(X)$. The standardized linear combination that results from the maximization of [17] is the first principal component y_1, while $y_1 = \gamma_1^T X$ holds. For the second principal component, the component with the second highest share of the total variance, $y_2 = \gamma_2^T X$ applies. Expressed in matrix notation the transformation can be generally postulated as (see HÄRDLE AND SIMAR [2007, p.217]):

[18] $$Y = \Gamma^T (X - \mu),$$

at which a mean-standardization ($E(X) = \mu$) is included and $Var(X)=\Sigma=\Gamma\Lambda\Gamma^T$ applies. For given $X \sim (\mu,\Sigma)$, thereby equation [18] is the component decomposition, the following relations hold:

[19] $$E(Y_j) = 0 \qquad j = 1,\ldots, p$$

[20] $$Var(Y_j) = \lambda_j, \qquad j = 1,\ldots, p$$

[21] $$Cov(Y_i, Y_j), \qquad i \neq j$$

[22] $$Var(Y_1) \geq Var(Y_2) \geq \ldots \geq Var(Y_p) \geq 0$$

[23] $$\sum_{j=1}^{p} Var(Y_j) = \mathrm{tr}(\Sigma)$$

[24] $$\prod_{j=1}^{p} Var(Y_j) = |\Sigma|$$

There exists no standardized linear combination with a greater variance than the first principal component $\lambda_1 = Var(Y_1)$). If $Y = a^T X$ is a standardized linear combination which is uncorrelated with the first k principal components, then the variance of Y is maximized via the choice of the (k+1)-th principal component. In practical applications the principal component decomposition is being substituted by the respective estimator (see HÄRDLE AND SIMAR [2007, p.219]). This means that μ is replaced by the mean of the variables and Σ by the empirically estimated covariance matrix S. The eigenvalues and eigenvectors of S are calculated afterwards. The components of these eigenvectors yield the weights of the original variables.

The interpretation of the derived principal components can be described as follows: Applied to business cycle indicators one wants to capture a factor or signal that acts behind the observable data; namely the common business cycle ("business cycle as a consensus"). The first principal component serves as proxy for this common cyclical movement by compromising the greatest component of common variance. The eigenvalue of this first principal component delivers insights into the economy's position within the business cycle. An increasing value gives a qualitative indication of rising economic activity and a decrease indicates a contraction of economic performance. The eigenvalues of the first principal component over time display the common cyclical component of the regarded indicators. The magnitude is rather arbitrary and has only reduced quantitative absolute interpretation, but is in relation quantitatively comparable relatively over time. The size of the first principal component also allows conclusions about how large the share of the variables is over time in reference to the total variance (that can be attributed to the common business cycle phenomenon).

Another widely-applied time serial method that can be used in the context of the aggregation of indicators are the dynamic factor models by STOCK AND WATSON [1989 and 2002]. They can additionally produce forecasts of the generated common factor.

2.A.2. Employed Indicators

The chosen indicators that have been selected according to the criteria mentioned in chapter 2.5. are listed in TABLE 47 and described in the following.

Individual Indicators	Source	Transformations	Publication Lag
Employed people	AfS	Q^-,S,T,N	2 months
Inward commuters	AfS	Q^-,S,T,N	2 months
Unemployed people [reciprocal value]	AMS	Q^-,S,T,N	0 months
Job openings [reciprocal value]	AMS	Q^-,T,N	0 months
Prices (LIK) [indexed]	BfS	Q^-,S,T,N	0 months
Gross domestic product [CHF, nominal]	KOFL	Q^+,D,S,T,N	2-6 months*
Exchange rate index [indexed]	SNB	Q^-,T,N	0 months
Exports [CHF, nominal]	EZV	D,S,T,N	1 months
Imports [CHF, nominal]	EZV	D,T,N	1 months
Newly registered cars	AfS	Q^-,S,T,N	2 months
Overnight stays	AfS	Q^-,S,T,N	3-6 months*
Consumer sentiment [indexed, average of CH and A]	Seco/EUK	Q^-,S,T,N	0 months
Overall situation (business survey) [indexed]	AfS	S,T,N	2 months
Capacity utilization (business survey) [indexed]	AfS	S,T,N	2 months
New orders (business survey) [indexed]	AfS	S,T,N	2 months
Earnings (business survey) [indexiert]	AfS	S,T,N	2 months
Sales (industry) [CHF, nominal, indexed]	StV	D,S,T,N	2-6 months*
Sales (financial services) [CHF, nominal, indexed]	StV	D,S,T,N	2-6 months*
Stock prices [CHF, nominal]	SIX	Q^-,D,T,N	0 months
Interest spread [%-points]	SNB	Q^-,T,N	0 months

AfS: Office of Statistics Liechtenstein (Amt für Statistik); BfS: Swiss Statistics (Schweizerisches Bundesamt für Statistik); SNB: Swiss National Bank (Schweizerische Nationalbank); AMS FL: Job Market Service Liechtenstein (Arbeitsmarktservice Liechtenstein); KOFL: Liechtenstein Economic Institute (Konjunkturforschungsstelle Liechtenstein); KOF: Swiss Economic Institute (Konjunkturforschungsstelle ETH Zürich); StV: Tax Administration Liechtenstein (Liechtensteinische Steuerverwaltung); EZV: Swiss Federal Customs Administration (Schweizerische Eidgenössische Zollverwaltung); EUK: European Commission (Europäische Kommission); SIX: Swiss Exchange; Seco: Swiss State Secretariat of Economic Affairs (Schweizerisches Staatssekretariat für Wirtschaft).
Q^-: generating quarterly figures (reduction of frequency); Q^+: generating quarterly figures (increase of frequency); D: Deflating (nominal to real figures); S: seasonal and calendar adjustment; T: trend removal; N: normalization.
* Faster availability in the future is very likely, but at the moment still subject to clarifications

TABLE 47: Individual indicators of composite index KOFL KonSens

Employment data can be regarded as important economic indicators. The number of *employed people* (domestic residents that work in Liechtenstein plus inward commuters) and *inward commuters* (domestic workers who live abroad) are published on an annual basis by the Office of Statistics, which confidentially provides monthly

data to Liechtenstein Economic Institute (Konjunkturforschungsstelle Liechtenstein, KOFL) for business analysis and research purposes. The figures of *unemployed people* and the number of *job openings* are being released monthly by Arbeitsmarkt Service Liechtenstein.

The *prices* are captured by the Swiss price index (Landesindex für Konsumentenpreise, LIK). It is measured monthly and released by the Swiss Office of Statistics (Bundesamt für Statistik, BfS). Since there exists no price index for Liechtenstein, the Swiss price index serves as proxy. The justification for this proceeding has been given at different occasions earlier in this manuscript.

The quarterly *gross domestic product*, which has been econometrically estimated from annual figures earlier in this text (chapter 2.4.), is also considered as a very important indicator for the KOFL KonSens. It will be continually estimated and revised in the future on a quarterly basis by KOFL.

Due to the small size of the domestic economy and the very high export orientation, Liechtenstein is highly dependent on the international business cycle (economic performance and demand of trade partners), on the quality of the exported products and also on the price competitiveness of the export sector. The price competitiveness is in turn not only a function of the directly set price but also of the Swiss Franc's exchange rate to currencies of trade partners. The *exchange rate index* captures the exchange rate of the Swiss Franc and foreign currencies, adjusted and weighted for the trade structure with the considered countries with another currency. This export-weighted exchange rate index is published by the Swiss National Bank (see SWISS NATIONAL BANK [2001]). It is computed by regarding all the exchange rates to the international currencies of trade partners (countries) and each real exchange rate is weighted according to the relative trade value of each country. A decrease of the index represents a real devaluation of the Swiss Franc (price competiveness rises) and vice-versa. The exchange rate index can also be

applied to Liechtenstein, but the trade weights have to be modified and transposed according to Liechtenstein's export mix. The Swiss Federal Customs Administration (Eidgenössische Zollverwaltung, EZV) releases the goods exports of Liechtenstein, broken down by each country. The EZV treats the country Liechtenstein as „Swiss Canton" due to the customs treaty between the two countries. The exchange rate data of the Swiss National Bank can also be applied for Liechtenstein, as it also uses the Swiss Franc as official currency. The remaining needed data source is the price index, which unfortunately does not exist for Liechtenstein. The Swiss price index can be used as a good proxy. As shown in BRUNHART [2006, p.106], the rather high effort to obtain an index for Liechtenstein in each quarter is not justified: The movement of the exchange rate index for both countries, Liechtenstein and Switzerland, is almost congruent for the tested time period (1998Q1 to 2005Q3). This is due to the inevitable application of the same price index and the similar international trade structure of both nations. Thus, the Swiss exchange rate index is applied as a proxy for the price competitiveness of Liechtenstein.

Liechtenstein's *exports* and *imports* are supplied by the Swiss Federal Customs Administration (Eidgenössische Zollverwaltung, EZV) on a quarterly basis. They consist of exports and imports of goods, exports and imports of services are not included. Additionally, imports and exports between Liechtenstein and Switzerland are not covered. The classification „total 1" of exports and imports is used for the KOFL KonSens, so the goods „noble metal and jewelry" and „objects of art and antiques" are excluded.

The *newly registered cars* statistics are monthly accessible from the Office of Statistics and denote the all newly registered cars in Liechtenstein, which are all subject to the registration process at the national vehicle inspection administration (Amtliche Motorfahrzeugkontrolle).

The data on *overnight stays* are accessible monthly and also issued by the national Office of Statistics. They include the number of nights spent by guests in hotels and hostels in Liechtenstein.

The *consumer sentiment* consists of the Swiss consumer sentiment (Konsumentenstimmung) published quarterly by Seco and the Austrian consumer sentiment (Verbrauchervertrauen) released monthly by the European Commission. Both are weighted equally in order to obtain the indicator for the KOFL KonSens. It can be observed that the consumer sentiments of the two countries are highly correlated. It is therefore reasonable to conclude that the consumer sentiment in Liechtenstein evolves similarly to those of its two neighbouring countries.

Overall situation (business survey), capacity utilization (business survey), new orders (business survey), and *earnings (business survey)* originate from the economic business survey by Liechtenstein's national Office of Statistics. The business survey is a qualitative (not quantitative) census of companies in the sectors industry and manufacturing and is carried out quarterly.

The two business cycle indicators *sales (industry)* and *sales (financial services)* are compiled by the national tax administration along with the value added tax computation process on a quarterly basis. They include the sales of the 25 largest corporations in Liechtenstein. This aggregated data is highly confidential but is provided to KOFL in aggregated form (percentage changes, not in levels). Building on these %-changes indexed series are constructed, whereby the fourth quarter of 1999 is the base quarter with the index value 100. By the submission date of this thesis sales data from the first quarter 1999 until the fourth quarter of 2011 is available. Clarifications about the possibility of a faster availability are in progress.
The stock values of all the quoted companies of Liechtenstein, Verwaltungs- und Privatbank and Liechtensteinische Landesbank AG, are averaged and denote the indicator *stock prices*.

Also the *interest spread* is considered. It is the difference of the yield of the Swiss confederation and the LIBOR (3-months) in percentage changes. The Swiss interest spread is also of high relevance because the banks of Liechtenstein belong to the Swiss banking system and monetary regime. It is also interesting to calculate Liechtenstein's interest spread. Unfortunately, the official banking statistic is published only on an annual basis. But Switzerland's and Liechtenstein's annual interest spread are highly correlated. Thus, the Swiss interest spread is used as quarterly proxy for Liechtenstein.

3.

Stock Market's Reactions to Revelation of Tax Evasion: An Empirical Assessment*

* An earlier version of this part of the dissertation (chapter 3) was published in BRUNHART [2012a] as *KOFL Working Paper* (No. 9, series issued by the KOFL Liechtenstein Economic Institute). The old title was „Evaluating the Effect of 'Zumwinkel-Affair' and Financial Crisis on Stock Prices in Liechtenstein: An 'Unconventional' Augmented GARCH-Approach".
I would like to thank *Prof. Robert Kunst* (University of Vienna), *Prof. Carsten Schlag* (University of Liechtenstein), *PD Dr. Kersten Kellermann* (Liechtenstein Economic Institute, KOFL), *Prof. Karl Schlag* (and the other participants of the "graduate and staff seminar" at University of Vienna), *Dr. Berno Büchel* (Saarland University), *lic.phil. Seraina Peter*, *Philippa Kitchen*, *Thomas Lageder, MA,* and *Walter Sinn* for useful comments. I also thank *Angelika Stöckel* and *Hendrik Breitenstein* from VP Bank and *Roman Frick* from LGT Bank for providing me the relevant time series.

3.1. Introduction

On February 14th (2008), German authorities arrested Klaus Zumwinkel, Chief Executive Officer and Chairman of Deutsche Post, in a very spectacular way at his home and in front of several TV-cameras: He was accused of tax evasion and subsequently resigned from office just a few days afterwards. Zumwinkel was convicted by the beginning of 2009. Along with about 600 other German tax evaders, Zumwinkel's tax fraud was unveiled by data provided by a whistle-blower named Heinrich Kieber, a Liechtenstein citizen, who is a former employee of the LGT Bank. He sold the data to the German Intelligence Service (Bundesnachrichtendienst, BND) for an estimated 5 Million Euros and also distributed the data to at least 13 other countries. Even though the identity of the whistle-blower was unveiled very soon, he could not be arrested yet and his domicile remains unknown despite the issue of an international arrest warrant in March 2008 by Liechtenstein's national police department.

This affair, named "Zumwinkel-Affair" or "Liechtenstein Tax-Affair" (or "German Tax Affair") by the press, led to stronger pressure on countries that were often called "tax-havens", especially Liechtenstein but as an indirect consequence later also on Luxemburg, Switzerland, Monaco and even Austria. The dramatic arrest of Zumwinkel ensured that the topic dominated the media for weeks not only in Germany and Liechtenstein, while harsh statements by several politicians and political pressure by Germany played an important role ensuring that the issue of tax information exchange remained on the diplomatic agenda of both countries and it still does.

Both international pressure and political debates within Liechtenstein, which had already been started before the data sale emerged, resulted in so far more than 25 tax information exchange agreements within the last three years. These new agreements led, among other things, to a still ongoing transformation process

affecting all actors within the financial sector of Liechtenstein (a detailed overview on the affair and its consequences is given in the appendix 3.A.5.). Combined with the already severe economic aftermath of the financial crisis the affair was a strong challenge especially for the financial sector but also for Liechtenstein's entire economy. The financial sector's challenge is still supplemented by the effort to pursue the now ongoing transformation process.

This chapter 3 puts emphasis on the analysis and quantification of the impact of the Zumwinkel-Affair on Liechtenstein's financial sector (in other words: the effect of the revelation of tax evasion on the stock market). This affair arose from the data theft and was followed by political pressure, irritated investors and was accompanied by a transformation process within Liechtenstein and recent tax information exchange agreements. So, the main question among others is: Did the Zumwinkel-Affair (data theft as an exogenous shock) affect the average return and influence the volatility of related stock values? And if yes, how?

As a reliable and frequently available indicator for the impact of the affair on Liechtenstein's financial sector, share prices of companies within the financial sector have been chosen: Daily return of stock prices of the financial institutes whose shares are traded at the Swiss stock market ("Swiss Exchange") are in main focus. These banks are "Verwaltungs- und Privatbank AG" and "Liechtensteinische Landesbank AG". The LGT Bank, from which the stolen bank data was, is not quoted at the Swiss Exchange and therefore not investigated here.[83] A portrait of the mentioned banks, further facts to the economic impact of the financial crisis and the tax affair on Liechtenstein and additional examples describing the high international pressure are outlined in the appendix (chapter 3.A.5.).

[83] As to be seen later on, it is remarkable how affected the other two banks were by the LGT's data theft. This also reflects the high level of following insecurity in the whole financial sector of Liechtenstein.

To separate the effect of the financial crisis on the market and on the investigated stock prices from the effect of the data theft, other factors, which account for the impact of the financial crisis and other market fluctuations, are included such as the Swiss Market Index (SMI) and other measures capturing the financial crisis. Though the impact of the financial crisis is also of interest, its analytical and econometric inclusion mainly contains the importance of isolating the effect of the "Zumwinkel-Affair" from other interference.

The econometric analysis carried out implies a modified Generalized Autoregressive Heteroskedasticity (GARCH)-model, named here as augmented amalGARCH. The basic GARCH-approach was introduced by ENGLE [1982], TAYLOR [1986] and BOLLERSLEV [1986]. This popular class of models has its main advantage in the explicit modelling of the conditional variance. These models basically feature two linked regression equations: One to estimate different influences on the investigated dependent variable (conditional mean equation) and a linked second equation to evaluate the influence of different sources on the residual's conditional variance (conditional variance equation). As additional yet "unconventional" feature of this analysis here the lagged squared residuals have been removed in the main model of this paper from the GARCH-specification and replaced by squared lagged observed variables such as past stock return and past stock market performance. This unconventional replacement revisits to some extent the approach of WEISS [1984].[84] A general to specific-approach trying to detect the optimal combinations of the just mentioned literature has been executed. Hence, in order to systematically classify the different approaches into a broader group this family of possible amalgams will be termed later on as amalGARCH. This new term and the chosen specification, an augmented amalGARCH(0,1,1), will be described in more detail in chapter 3.2.2. when the development of the model setup is described. It turns out that the chosen specification featuring this replacement is superior in this application, which is

[84] KUNST [1997] investigated both specifications after ENGLE [1982] and after WEISS [1984] considering stability conditions and empirical evidence. See also TSAY [1987] for the discussion of related model classes.

rather exceptional. Additional explanatory variables have been incorporated into the (therefore augmented) variance equation to evaluate the impact of the financial crisis and the effect of the Zumwinkel-Affair on the equity risk. Including additional explanatory variables into the variance equation is unusual but appears to be valuable in this context of investigation.

The applied approach is beneficial from two points of view: First of all, there is direct interest in the effect of the Zumwinkel-Affair on average returns and volatility. It therefore makes sense to incorporate some measures regarding the impact of this affair into the mean equation and into the variance equation. Secondly, different channels of influence of past shocks are made visible by introducing additional explanatory variables such as the past squared returns of the particular stock value and the squared percentage change of the whole market index and also potential shocks on either or both of them. These are valuable supplements to the conventional components of the variance equation, the past conditional variance and undefined past shocks via the past squared residual. In this manner, a more precise understanding is obtained via which channels past shocks translate into rising volatility of the stock prices.[85] Thirdly, from an econometric point of view, the chosen "unconventional" augmented GARCH-model appears to be an improved alternative to the popular GARCH(1,1)-model, which is the usually applied benchmark and would represent a non-augmented amalGARCH(1,1,0) in the introduced notation.

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[85] The introduction of KOLLIAS, PAPADAMOU AND SIRIOPOULOS [2012] gives a broad overview on studies considering exogenous events, such as terrorist attacks, natural disasters, aviation crashes and many more. Other contributions that investigate the impact of certain events, such as shocks on the mean and volatility of markets or even whole economies (as well in an ARCH-framework like it is done in the contribution here) are for example ASTERIOU AND PRICE [2001], ELYASIANI, MANSUR AND ODUSAMI [2011] and HAMMOUDEH AND YUAN [2007]. They generally apply an ordinary GARCH(p,q)-approach. These would be amalGARCH(p,q,0) models (in the notion introduced later), supplemented by dummies and other explanatory variables. Here, in this unconventional approach, the past squared residuals are dropped from the variance equation that includes lagged squared terms of the dependent variable instead, also augmented by dummies and lagged squared independent variables. This corresponds to an augmented amalGARCH(0,q,s).

After this introduction section 3.2. deals with the estimation of the augmented amalGARCH-model for the two different stock prices. To obtain an auxiliary classification the applied models and especially the chosen optimal model are systematically integrated into this new term "amalGARCH". Following a descriptive and visual investigation of the used data series, further econometric considerations are presented and the estimation process of the daily stock prices of the banks Verwaltungs- und Privatbank and Liechtensteinische Landesbank are outlined. Furthermore, the impacts of the financial crisis and the Zumwinkel-Affair on performance and risk are assessed. Also, the results of the two investigated stocks are compared. In section 3.3., the text concludes with some summarizing and complementary remarks.

3.2. Investigating the Impact on Stock Prices and Risk

After having shortly introduced the main motivation and goals of this paper's economic examination using linear and nonlinear econometric techniques, the first step would be to carry out visual explorations and to calculate descriptive statistics of the relevant time series. The used data series in the presented contribution are the two stock prices of the two banks "Verwaltungs- und Privatbank AG" (VPB) and "Liechtensteinische Landesbank AG" (LLB) which have their headquarters in Vaduz (Liechtenstein).[86] Both stocks are traded at the Swiss Stock Exchange in Zürich. Also, the Swiss Market Index (SMI) is taken into account to capture the fluctuations of the whole market. The Swiss Market Index (SMI) is an index including the values of the twenty most important Swiss stocks (called blue chips) which normally account for approximately 90 percent of the whole trading volume at the Swiss Stock Exchange. The investigated time frame for all the series spans from 2006 (January 1st) to 2011 (January 4th) including about 1'260 observations. Additional to these variables two time dummy variables are introduced to capture the impact of the "Zumwinkel-Affair" and the additional effect of the financial crisis on the banks' stock prices (that was not already captured by the impact of the financial crisis on the SMI, that in turn is correlated with the stock prices of the two investigated financial institutes). Also their impact on the conditional variance (volatility) of the stock prices is analysed.

3.2.1. Visual and Descriptive Analysis of Data Series

Before the adopted model will be illustrated in further detail, it is important to pay deeper attention to the used data series. Inspecting the graphical movement of the employed time series (plotted in FIGURE 47) provides a few crucial insights. After

[86] All the mentioned banks and further information regarding the Zumwinkel-Affair are outlined in the appendix (3.A.5. and 3.A.6).

the economic expansion phase that affected most sectors of the economy up to 2007 there is a clear downward tendency beginning to be evident from the end of that year on. There was a certain period of consolidation during 2008 before the dramatic worldwide downturn on the international stock markets took place, following the crash of Lehman Brothers in September 2008 that led to a long lasting decrease. The financial crisis, which had its origin already in the American sub-prime crisis, is clearly visible with its extremum at the trough in March 2009 in the Swiss Market Index.

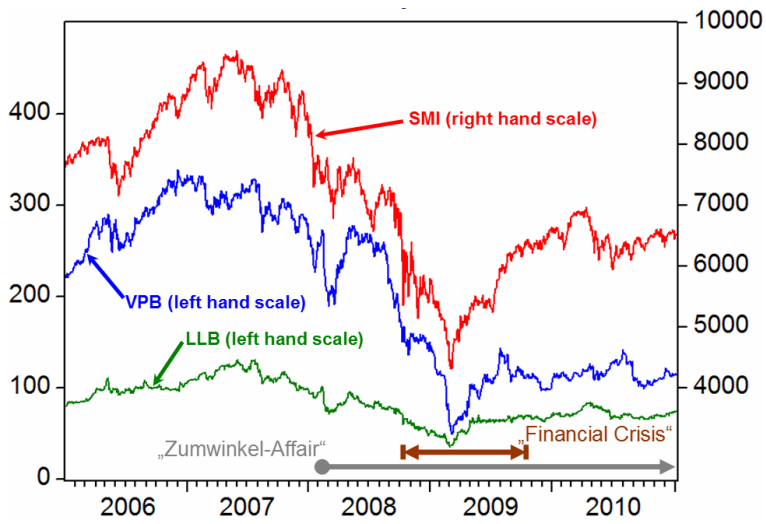

FIGURE 47: Daily stock prices of the VPB and the LLB compared to Swiss Market Index (SMI)

The two arrows in the graph of FIGURE 47 mark the chosen time periods for the two important time dummies (accounting for the financial crisis and the "Zumwinkel-Affair") which are used in the regressions later on. The SMI has been chosen as reference to identify the time period when the financial crisis was at its maximum. It is important to note that the time span also includes the period of recovery to the level, where the beginning of the crisis has been detected. The chosen timing of the two dummies is motivated as follows: The time period of the dummy of the financial crisis starts with the crash of Lehman Brothers on October 6th 2008 and ends where the SMI was back again on the same index level before the crash on October 16th 2009. The time dummy for the Zumwinkel-Affair starts one day after the arrest of Klaus Zumwinkel on February 15th (this event has also

induced a notable temporary downturn shock in the SMI) until the end of the inspected sample period on January 4th 2011.

It is important to stress some facts which might not be fully apparent at first sight due to the different scaling of both axes in FIGURE 47: On the one hand, it is easily visible that the SMI and the two banks' shares are strongly related and that all of them experienced a sharp decrease in their stock values after the peak in the middle of 2007 until the trough in March 2009. But on the other hand, the investigated banks suffered from even more dramatic losses than the market. While the SMI lost around 55%, the LLB-stock decreased around 75% and the VPB-stock value even diminished around 85%. Inspecting the two stocks an additional drop is visible in February 2008, exactly when the "Zumwinkel-Affair" began. It is evident that the recovery of the SMI after the financial crisis was stronger compared to the LLB and VPB, not in percentage recovery compared to the lowest through but compared to the level in the boom-year 2007. One possible explanation is the data theft that resulted in the "Zumwinkel-Affair", which was followed by high international pressure on Liechtenstein leading to a deep and still ongoing transformation process within the financial sector, as reasoned in the introduction of this paper.

All the three used data series are integrated of order one[87], so if they are just plugged in original form into the estimation process one is running a high risk of generating estimates which have been affected by spurious regression, an instance that could result in misleading estimation results.[88] The original data series have been

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87 Augmented Dickey Fuller-test (DICKEY AND FULLER [1979]), KPSS-test (KWIATKOWSKI ET AL. [1992]) and Phillip/Perron-test (PHILLIPS AND PERRON [1988]) all suggest that the series feature a unit root (follow a random walk). After differencing, the series are integrated of order zero (same tests indicate no unit root anymore).

88 GRANGER AND NEWBOLD [1974] pointed out the problem and consequences of spurious regression potentially leading to falsely low p-values and high R^2. They also proposed a rule of thumb for the detection of spurious regression: If the goodness-of-fit measure R^2 is almost equal to 1 or higher than the reported value of the Durbin-Watson statistic then spurious regression "must" be present. The Durbin-Watson test checks the presence of serial correlation of first order among the errors of the model and was introduced by DURBIN AND WATSON [1950]. Especially the high R^2 or the very low durbin-watson statistics (of different specifications of the model, also with and without incorporation of a GARCH-specification)

transformed in order to obtain the daily percentage changes that are from now on denoted as %Δ*SMI*, %Δ*VPB*, and %Δ*LLB*. The plot of the transformed series is shown in FIGURE 48. Even though the transformation into percentage differences makes it more difficult to judge the long-term effects (which are not in main focus, however), especially of the "Zumwinkel-Affair" on the performance of the stock prices, it has one important benefit compensating for the just mentioned shortcoming: It provides a sort of "standardized" conditional variance since the models all contain the included series in percentage figures which make the conditional variances directly comparable over the whole time span and also between the two stocks used as dependent variables.

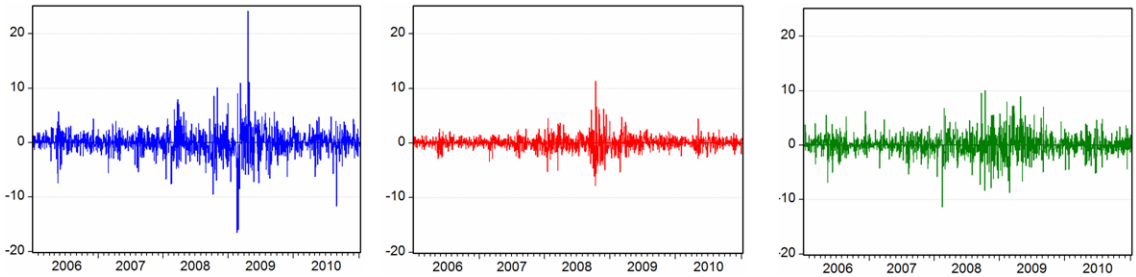

FIGURE 48: Daily percentage changes of the SMI (red middle graph), the VPB-stock prices (blue left graph) and the LLB-stock prices (green right graph) from 2006 until 2010

If one compares the plot of the daily percentage change of the three time series one recognizes that all the series feature visible volatility clustering, which looks like a seismographic detection of equity risk. A rise of volatility is detectable during the period of the financial crisis (October 2008 until October 2009) but also (albeit comparably lower) at the time point when the data theft became public (in February 2008). It can also be observed that both stocks have a higher range and volatility than the Swiss Market Index (especially the VPB-stocks), something that also becomes apparent when the descriptive statistics are calculated and compared

led to only one possible conclusion that spurious regression is existent if we use the variables in levels. The durbin-watson test should be treated with care if there is a lagged dependent variable in the estimated equation (or if the constant is dropped). Nonetheless, the impression of spurious regression was independent from different executed specifications excluding/including a constant or a lagged dependent variable.

(expressed in the table of TABLE 48). The standard deviations of the two stocks are higher than the standard deviations of the market index, while all are alike when it comes to comparing their fourth moments: They all have a kurtosis that is considerably higher than 3 (a kurtosis of 3 would correspond to a normal distribution). Thus, the three series have leptokurtic properties featuring "heavy-tails".

Descriptive Statistics	%ΔVPB	%ΔSMI	%ΔLLB
Mean (1st moments)	-0.0224	-0.0035	0.0149
Median	0.0000	0.0496	0.0000
Maximum	24.1782	11.3910	10.0000
Minimum	-16.5276	-7.7881	-11.3918
Std. dev. (2nd moments)	2.4599	1.3427	2.0472
Skewness (3rd moments)	0.2726	0.3070	-0.0167
Kurtosis (4th moments)	15.0161	11.0651	6.3034

TABLE 48: Descriptive statistics of the three series used in the explorations

More on the leptokurtic features and the pattern of autoregressive conditional heteroskedasticity regarding the two investigated stock series will be discussed in the appendix (section 3.A.4.).

3.2.2. Model Setup

Neglecting the presence of ARCH (autoregressive conditional heteroskedasticity)-effects, that were detected in the last chapter, in regression models results in inefficient ordinary least squares estimates (yet, still being consistent). The covariance matrix of the parameters might be biased, with invalid t-statistics (see ASTERIOU AND HALL [2007, p.252-253]). Besides the lack of asymptotic efficiency (see ENGLE [1982]), it might also lead to over-parameterization of an (ARMA)-model (see WEISS [1984]) and to over-rejection of conventional tests (see MILHØJ [1985]), for example tests for serial correlation (see also FAN AND YAO [2005, p.165]). Setting up a model which explicitly accounts for the presence of ARCH-

effects leads to an efficient estimator and will ensure the calculation of a valid covariance matrix. However, such a model is not estimated by an ordinary least squared estimator, but by the iterative solving of a nonlinear maximation problem, namely by using a maximum-likelihood procedure.[89] Hence, instead of only estimating the mean equation (Y_t) of the following equations the variance equation with the conditional variance (h_t) is also included:

$$Y_t = \alpha_1 + \beta_1 X_{1t} + \ldots + \beta_k X_{kt} + u_t \qquad u_t \mid \Omega_t \sim \mathrm{N}(0, h_t) \qquad \sigma_t^2 := h_t$$

$$h_t = \alpha_2 + \sum_{i=1}^{p} \gamma_i u_{t-i}^2$$

X_1 to X_k are linear predictors of Y. The specification of the conditional variance resembles the conception of ENGLE [1982]. Of course, also lags of the independent and the dependent variable are includable into the just reported mean equation. But these have been excluded in the term of this short overview.

BOLLERSLEV [1986] and TAYLOR [1986] developed a more general approach also considering the possibility of an autocorrelated conditional variance (h_t). The variance equation of this widespread GARCH-approach therefore is of the following form:

$$h_t = \alpha_2 + \sum_{i=1}^{p} \gamma_i u_{t-i}^2 + \sum_{j=1}^{q} \delta_j h_{t-j}$$

[89] The maximum likelihood estimation procedure basically chooses the optimal coefficients within the (conditional) mean equation by maximizing a log likelihood function term, which is mainly dependent on the error term and the error variance. This procedure now provides efficient and consistent estimates within both the mean and variance equation. OLS may serve as an instrument to find good starting values for the iterative maximum likelihood estimation. The (conditional) variance equation itself is not really a regression equation in the usual sense, the chosen parameter values are found by the fact that they affect the (conditional) error variance, which appears in the log likelihood function of the mean equation. The log likelihood function is also of further importance with respect to the determination of the lag order of the GARCH-specification as it is the main element of the information criteria mentioned later on.

WEISS [1984] as well introduced a more general form of the original ARCH-model. He additionally incorporated a dependency of the conditional variance on the past squared observed values of the dependent variable of the mean equation (Y_t):

$$h_t = \alpha_2 + \sum_{i=1}^{p} \gamma_i u_{t-i}^2 + \sum_{l=1}^{s} \beta_{k+l} \cdot Y_{t-l}^2$$

Note that WEISS [1984] also integrated squared independent variables (coincident and/or lagged) from the mean equation into the variance equation (see also WEISS [1986, p.109] and HAUSER AND KUNST [1993, p.7]). But the inclusion of independent variables into the variance equation is labelled by the term "augmentation" of the core classification which is just being introduced.

In a general-to-specific manner, which is executed in the main model set up of the investigations of this paper, the conditional variance shall be allowed to be a function of the past residuals, the past conditional variance and the past dependent variable in squares.[90]

$$h_t = \alpha_2 + \sum_{i=1}^{p} \gamma_i u_{t-i}^2 + \sum_{j=1}^{q} \delta_j h_{t-j} + \sum_{l=1}^{s} \beta_{k+l} \cdot Y_{t-l}^2$$

As explained later on, this general-to-specific approach can and will be augmented by lagged independent variables in squares and some time dummies. Also, the independent variables could also be included in a coincident (non-lagged) manner or in non-squared form, but both of these extensions are not of central interest from an analytical point of view and have not been applied here.

A new term is being introduced here, in order to provide a certain system of the different related approaches and specifications of the variance equation to model heteroskedasticity,. The term incorporates the different features proposed by ENGLE [1982] (past squared residual), WEISS [1984] (past squared dependent

[90] Note that the model is not identified if Y is white noise. If autocorrelation of Y is weak it becomes difficult to separate the gamma and the beta terms.

variable) and BOLLERSLEV [1986] (past conditional variance). The family of all possible combinations or amalgams of these mentioned approaches is now called "amalGARCH(p,q,s)"[91], where p is the lag-length of the squared residual, q the lag-length of squared dependent variance and s the lag-length of the dependent variable.

Apart from the afore-mentioned econometric advantages, there are also analytical reasons why an amalGARCH-approach is used here, since there is direct economic interest in the impact of certain events, such as the financial crisis and the "Zumwinkel-Affair", on volatility (which is measured by the conditional variance equation explained later on). These two events are captured by two time dummies. Also, past shocks in the market, measured by the squared past percentage change of the SMI, and their impact on the current conditional variance of the stocks returns are of central relevance. Thus, the variance equation is additionally modified and augmented by the three just mentioned variables:

$$\begin{aligned}\%\Delta STOCKPRICE_t &= \beta_1 \cdot \%\Delta STOCKPRICE_{t-1} + \beta_2 \cdot \%\Delta SMI_t \\ &\quad + \beta_3 \cdot DATATHEFT_t + \beta_4 \cdot FINANCIALCRISIS_t + u_t\end{aligned}$$

$$u_t | \Omega_t \sim \mathrm{N}(0, h_t)$$

$$\begin{aligned}h_t &= \alpha + \sum_{i=1}^{q} \delta_i \cdot h_{t-i} + \sum_{j=1}^{p} \gamma_j \cdot u_{t-j}^2 + \sum_{l=1}^{s} \beta_{4+l} \cdot \%\Delta STOCKPRICE_{t-l}^2 + \beta_{4+l+1} \cdot \%\Delta SMI_{t-1}^2 \\ &\quad + \beta_{4+l+2} \cdot DATATHEFT_t + \beta_{4+l+3} \cdot FINANCIALCRISIS_t\end{aligned}$$

The applied modelling strategy is therefore called "augmented amalGARCH". As it appears later on, the optimal specification happens to be the unconventional augmented amalGARCH. In TABLE 49 the three popular classes of models from the literature that have already been explained earlier are being listed and classified within the newly defined amalGARCH model-class. The term "augmentation" concerns the supplementation of the time dummies and the past independent variable and relates to the columns four and five in the table. The applied model is

[91] The here chosen notation "amalGARCH", was inspired by HAUSER AND KUNST [1993, p.7] who state that the original approach of WEISS [1984] allows "…amalgams of Engle-type dependence on past errors and […] as well as for explicit dependence on the squared linear predictor for [the dependent variable]…".

"unconventional" because it is a modification to the commonly used ARCH- and especially popular GARCH-approaches, these two conventional types only have check marks in the first two columns of TABLE 49.

	Different amalGARCH(*p,q,s*)-specifications			Possible Augmentation	
	Past Squared Residual: (*p*)	Past Conditional Variance: (*q*)	Past Squared Dependent Variable: (*s*)	(Past) Squared Independent Variables	Dummies
ENGLE [1982]: ARCH	✓				
WEISS [1984]	✓		✓	✓	
BOLLERSLEV [1986]: GARCH	✓	✓			
Augmented amalGARCH(p,q,s)	?	?	?	✓	✓

TABLE 49: Popular and applied specifications within the amalGARCH-family

So, the popular ARCH-type of ENGLE [1982] would correspond to the term amalGARCH(p,0,0), the widely-applied GARCH-model by BOLLERSLEV [1986] is an amalGARCH(p,q,0) and the approach by WEISS [1984] an amalGARCH(p,0,s).

The estimation consists of two linked equations: The mean equation models the daily percentage change (return performance) of the stock value and the variance equation contains the conditional variance as a measure for the risk of the stock value. The influence on performance, in a first stage of the price of the VPB-stock and in a second stage of the price of the LLB-stock, is modelled as follows:[92]

- *Dependent variable*: The daily percentage change of the stock price (either %-change of VPB-stock price or %-change of the LLB-stock price) is used as regressand in the mean equation.

- *Control variables*: The present performance of the Swiss Market Index (%-change of SMI-value) and the past performance of bank's stock price (%-change of VPB or LLB) are used as regressors.

[92] The prefix "%Δ" (in the text) and "PD_" (in estimation output tables) are applied to label the percentage change/percentage difference of a variable. The suffix "(-1)" in the estimation outputs highlights the lagged variables indicating the usage of the observed value from one trading day in the past (in time point *t*-1) compared to the dependent variable's observation in time point *t*.

- *Additional impact of financial crisis*: A time dummy from October 6th (2008) until October 19th (2009) is generated to cover the impact of the financial crisis (the motivation behind the timing has already been outlined in chapter 2.1.). In the case of the mean equation the time dummy can be interpreted as the additional effect of the crisis beyond the influence which is already captured by the bad performance of the SMI. So, this dummy tries to check if the stock value has suffered more severely (or less) compared to the market regarding the average returns. The detailed interpretation will be given in the next two sections.

- *Additional impact of data theft ("Zumwinkel-Affair")*: Another time dummy from February 15th (2008), when the arrest of Zumwinkel took place, until January 4th (2011), which is the end of the sample, is integrated to measure the additional impact of the "Zumwinkel-Affair", separated from the impact of the financial crisis. The incorporations of the financial crisis dummy and the %-change of the SMI allow the estimated impact of the "Zumwinkel-Affair" not to be heavily biased by the financial crisis.

Of particular interest is the augmented GARCH-specification of the variance equation: The past squared residuals and the past conditional variances are supplemented by the same control variables as in the mean equation, but now in squared form. The reason for taking squares is to ensure that both past negative and past positive outbursts have the same (presumably increasing) effect on volatility measured by the conditional variance. The variance is also augmented by the time dummy variables "financial crisis" and "data theft".

The chosen time span also includes the period of recovery to the level, where the beginning of the crisis' peak has been detected in FIGURE 49. It would be unreasonable to argue that the crisis was overcome right after the lowest trough. The decision to include some amount of recovery will surely affect and lower the

estimated (presumably negative) impact of the crisis on the conditional mean of stock values, since they are highly correlated with the SMI. The consequences of the inclusion of the recovery period on the conditional variance are hard to guess in an early stage, but this decision seems to be fairly reasonable and will be explored later on.

Different specifications of the variance equation have been exercised and explicitly compared with the applied augmented amalGARCH(0,1,0)-model: An augmented amalGARCH(1,1,0)-model, where the lagged squared observations of the stock returns and of the SMI-performance have been removed from the variance equation and the typical "non-augmented" amalGARCH(1,1,0)-model, which is equivalent to the traditional term "GARCH(1,1)", are applied as benchmarks. It turns out that the chosen augmented amalGARCH(0,1,1)-specification is not only justified by the aim of the analytical investigations but also proves to be superior to the alternative specifications (see the appendix for the details).

As noted, the variance equation will be in main focus (the determinants of the volatility of the stock prices) rather than the mean equation (the determinants of the percentage change of the stock prices), as stock returns are usually hard to model and predict, while the evaluation of the expected risk is more promising and yields more relevant information about investment decisions.

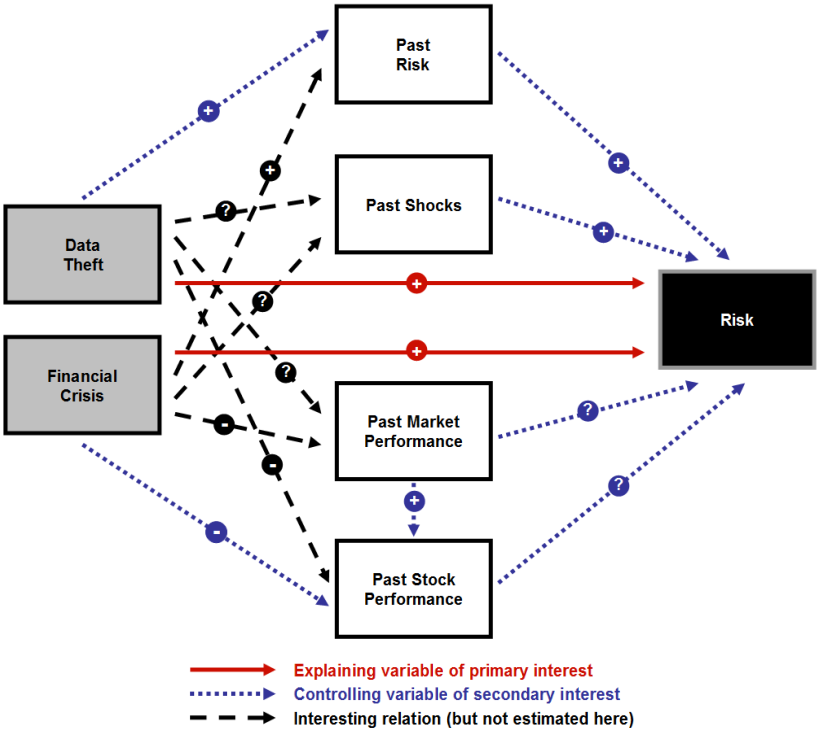

FIGURE 49: Included variables (within the variance equation) and expected signs of influence

FIGURE 49 summarizes all the variables, which are incorporated into the variance equation and therefore capture the influences of primary interest, namely the various determinants for the prediction of risk (volatility) of the investigated stock return: As already explained, in main focus are the effects of the data theft and of the financial crisis. A priori, it is expected that both influences of primary interest have an accumulating effect on equity risk (hence marked with a positive sign), so it is assumed that both events have increased volatility. The observable volatility clustering suggests high positive autocorrelation of risk itself. Past shocks, captured by high values of past residuals within the mean variance, will presumably result in higher risk. Also, high absolute values of past percentage changes of the SMI and of the inspected stock value presumably have an accumulating effect on risk (but this should be estimated first before it is stuck to this claim). The interrelation of the past market performance and the financial crisis with the past stock performance is being dealt with as well within the mean equation.

3.2.3. Results and Interpretation

As already outlined in the previous section, the three regarded series feature leptokurtic patterns, the reported kurtosis is for all the three series considerably above 3. The sample distribution and quantiles of the returns of the VPB-stocks and LLB-stocks have been compared with the adjusted normal distribution and an ARCH-test (following ENGLE [1982]) has been executed to confirm this descriptive detection of autoregressive heteroskedasticity: Both methods clearly indicate the existence of ARCH-effects (outlined in the appendix 3.A.4.). Also, the positive serial autocorrelation of the residuals (from an "ordinary" model fitting without GARCH-specification) and the autocorrelation functions of $\%\Delta VPB$ and $\%\Delta VPB^2$ ($\%\Delta LLB$ and $\%\Delta LLB^2$) underline the existence of serially correlated variance, which is visible in the volatility clustering. The existence of autoregressive conditional heteroskedasticity makes the introduction of a variance equation (GARCH-approach) particularly lucrative, besides the fact that there exists direct interest in the different influences not only on the performance but especially on the equity risk (measured by the conditional variance).

The econometric setup of the used amalGARCH(p,q,1)-model with a mean equation (with either $\%\Delta VPB_t$ or $\%\Delta LLB_t$ as dependent variable) and a variance equation (with the conditional variance h_t as dependent variable) is depicted below[93]:

$$
\begin{aligned}
\%\Delta VPB_t &= \alpha_1 + \beta_1 \cdot \%\Delta VPB_{t-1} + \beta_2 \cdot \%\Delta SMI_t \\
&\quad + \beta_3 \cdot DATATHEFT_t + \beta_4 \cdot FINANCIALCRISIS_t + u_t \\
u_t \,|\, \Omega_t &\sim \text{iid N}\left(0, h_t\right) \\
h_t &= \alpha_2 + \sum_{j=1}^{q} \delta_j \cdot h_{t-j} + \sum_{i=1}^{p} \gamma_i \cdot u_{t-i}^2 + \beta_5 \cdot \%\Delta VPB_{t-1}^2 + \beta_6 \cdot \%\Delta SMI_{t-1}^2 \\
&\quad + \beta_7 \cdot DATATHEFT_t + \beta_8 \cdot FINANCIALCRISIS_t
\end{aligned}
$$

93 The time period of the financial crisis time dummy lies entirely within the time span of the data theft dummy: The included dummy variable $FINANCIALCRISIS_t$ is therefore fully equivalent to the interaction variable $DATATHEFT_t$*$FINANCIALCRISIS_t$. This reasoning is also supported by the empirical results, which are completely the same for both specifications. In the forthcoming econometric analysis in this paper, the variable $FINANCIALCRISIS_t$ is used instead of the interaction term.

$$
\begin{aligned}
\%\Delta LLB_t &= \alpha_1 + \beta_1 \cdot \%\Delta LLB_{t-1} + \beta_2 \cdot \%\Delta SMI_t \\
&\quad + \beta_3 \cdot DATATHEFT_t + \beta_4 \cdot FINANCIALCRISIS_t + u_t \\
u_t \,|\, \Omega_t &\sim \text{iid N}\left(0, h_t\right) \\
h_t &= \alpha_2 + \sum_{j=1}^{q} \delta_j \cdot h_{t-j} + \sum_{i=1}^{p} \gamma_i \cdot u_{t-i}^2 + \beta_5 \cdot \%\Delta LLB_{t-1}^2 + \beta_6 \cdot \%\Delta SMI_{t-1}^2 \\
&\quad + \beta_7 \cdot DATATHEFT_t + \beta_8 \cdot FINANCIALCRISIS_t
\end{aligned}
$$

After adjustments both equations include 1'256 observations. The lag lengths in the variance equation, namely of the past variances and the past squared residuals (obtained from the mean equation) have been determined with respect to different information criteria, also keeping in mind the conditions for a valid GARCH-model and the significance of the GARCH-coefficients[94].

The following passage repeats the setup of the model and already points out the main results obtained from the augmented amalGARCH(0,1,1)-model, whose output is visible in TABLE 50. The influence on daily percentage change of stock prices (%Δ*VPB* and %Δ*LLB*) is captured by the mean equation:

- *Constant*: The constant was excluded since it was insignificant and led to worse information criteria. However, the main results remained insensitive to the inclusion or exclusion of the constant.

[94] The information criteria (even though these criteria can sometimes have problems with finding a minimal extremum in the context of GARCH-models) deliver very important insights (see NEUSSER [2006, p.145]): The criteria clearly suggest a very parsimonious amalGARCH(0,1,1)-specification. Higher amalGARCH-orders (especially of past squared residuals) generate unacceptably many insignificant estimates and even negative coefficients (which is invalid). Thus, it is implausible to incorporate past observations (of variables from the mean equation) plus past squared residuals (of the mean equation) into the variance equation. The opposite approach of dropping the variables %Δ*VPB*(-1)^2 and %Δ*SMI*(-1)^2 from the variance equation (and including past squared residuals instead) is shown in the appendix. The alternative GARCH(1,1) yields very similar results with respect to the investigated variables compared to the approach outlined in this and the next section. Additionally, a typical benchmark model like the "non-augmented" GARCH(1,1)-approach, which is equivalent to a non-augmented amalGARCH(1,1,0), has been executed and compared with the two other specifications. As already pointed out, the chosen augmented amalGARCH(0,1,1) turns out to be the best specification (see the appendix).

- *Control variables*: The performance of the Swiss Market Index (%-change of SMI) is highly significant meaning that general market fluctuations are closely related to the VPB-stocks, while the past performance of the bank's stock price (lagged %-change) plays only a minor role. The performance of the Swiss Market Index (%-change of SMI) is highly significant also in the case of the LLB, so the general market fluctuations are an important influence for both stocks. The past performance of LLB's stock price (in contrast to the VPB) plays also a role: Even though the coefficient of the lagged dependent variable is rather small it is significant and negative.

- *Additional impact of financial crisis*: The insignificance of the time dummy indicates that there is no additional effect. Nonetheless, it would be wrong to conclude that there was no impact of the financial crisis at all, since it is reasonable to argue that the financial crisis was already captured by the bad performance of $\%\Delta SMI$ (which significantly affects the %-change of the VPB-stock and LLB-stock). Thus, the financial crisis had a negative impact on the daily returns. But this is also incorporated into the influence via the SMI. So there was no impact of the financial crisis that was bigger than the effect of the crisis on the whole stock market (ceteris paribus). Additionally, another fact contributes to the insignificance of the crisis, which even remains if the SMI-variable is removed from the estimation: Inspecting FIGURE 48 it can be observed that not only the SMI fully recovers from the sharp downturn (the time span dummy was set according to this fact on purpose) but also the VPB-stock price recovers as both variables are highly correlated. Thus, the effects during the downturn and the upturn cancel out. If the duration of the crisis is shortened, so that only the downturn of the market is included until the trough on March 9th (2009), then the financial crisis dummy gets significant (this is shown in the appendix 3.A.3.). Hence, two things can be concluded: First, the financial crisis had no additional impact on the VPB stock average returns if the recovery phase is included

into the financial crisis time definition. Second, it suffered from the financial crisis during the downturn phase even more than the market. This insignificance is also the case for both stocks if the time span of the financial crisis time dummy is shortened to leave out the recovery period but only for the LLB-stock if the SMI-variable is dropped within the estimation using the shorter period definition (for detailed results see the appendix 3.A.3.). Thus, the insignificance tells us two things: First, the financial crisis had no impact on the LLB-stock average returns that was more severe compared to the market not in the downward phase and not if the recovery period is included into the time definition of the financial crisis. Second, the LLB-stock only suffered from the financial crisis during the downturn phase (very similar to the market performance).

- *Impact of data theft*: This time dummy captures the impact of the "Zumwinkel-Affair", separated from the impact of the financial crisis and the ordinary market fluctuations, on daily returns ($\%\Delta VPB$ and $\%\Delta LLB$). No significant (additional) effect can be discovered consulting the estimation results of the mean equation.

As already noted, it is also of central relevance to inspect the effect of the involved variables on the conditional variance of the stock prices. The influence on volatility (as a measure for risk) is modelled by the variance equation with the conditional variance as the explained variable:

- All the estimated coefficients of the included variable are statistically significant and with expected positive signs, meaning that they all have a traceable accumulating effect on risk.

- The constant and the past conditional variance as explanatory variables within the variance equation are both highly significant. So, there is a

generally existent average risk (not explained by the market risk or the other considered variables).

- The squared control variables ($\%\Delta VPB^2_{t\text{-}1}$ and $\%\Delta SMI^2_{t\text{-}1}$) are also significant but contribute to a lower extent than the other included variables to the conditional variance. The squared control variables $\%\Delta LLB^2_{t\text{-}1}$ and $\%\Delta SMI^2_{t\text{-}1}$ are also significant in the LLB equation but have a lower impact on the conditional variance.

- Most interestingly, the two dummy variables are highly significant and intensify the variance: Hence, it can be concluded that the financial crisis had a very strong effect on the volatility during the period when the crisis took place. Additionally, the data theft/"Zumwinkel-Affair" also intensified the volatility/risk of the daily VPB-stock returns to a high extent. The data theft also intensified the volatility/risk of the daily LLB-stock returns, but the effect was weaker (the magnitude of the effect can also be seen in the plotted conditional variance of FIGURE 51). Both the effects of the Zumwinkel-Affair and of the financial crisis are considerably lower compared to the effect on the conditional variance of $\%\Delta VPB$ (see regression results in TABLE 50). The strength of the two events measured by the dummies on the magnitude of the volatility can be seen by comparing the considerable size of the coefficient with the constant of the variance equation that measures the average risk.

	Dependent Variable	
	$\%\Delta VPB_t$	$\%\Delta LLB_t$
Mean Equation		
$\%\Delta VPB_{t-1}$	-0.0102	
$\%\Delta LLB_{t-1}$		-0.0869***
$\%\Delta SMI_t$	0.5941***	0.4170***
Financial Crisis	-0.0196	0.0784
Data Theft	-0.0179	-0.0106
Variance Equation		
Constant	0.3073***	0.4217***
$ARCH(1): \hat{u}^2_{t-1}$		
$GARCH(1): h_{t-1}$	0.6452***	0.5331***
$\%\Delta VPB^2_{t-1}$	0.1085***	
$\%\Delta LLB^2_{t-1}$		0.1639***
$\%\Delta SMI^2_{t-1}$	0.1699***	0.2450***
Financial Crisis	1.9821***	1.2248***
Data Theft	0.4550***	0.1617**
Measures of Fit		
R^2	0.1255	0.0774
Adjusted R^2	0.1192	0.0707

TABLE 50: Estimation output of applied amalGARCH(0,1,1)-model

The augmented amalGARCH(0,1,1)-model therefore suggests that there is a certain path dependency (serial correlation) of volatility of the examined dependent variable $\%\Delta VPB$, but there is no autocorrelation of the variable $\%\Delta VPB$ itself. This means that even though the stock return itself cannot be well predicted by its own observable past (which conforms to the often quoted market efficiency hypothesis), the risk, measured by the conditional variance, can be predicted to a certain extent using the past observed variables within the variance equation[95]. Interestingly, it turns out that there is a certain path dependency (serial correlation) of the volatility of the examined dependent variable $\%\Delta LLB$ <u>and</u> that there is, in contrast to $\%\Delta VPB$, also significant autocorrelation of the variable $\%\Delta LLB$ itself: The lagged dependent variable $\%\Delta LLB_{t-1}$ is significant and the negative autocorrelation exhibits a significant Ljung-Box-Q-statistic, with a p-value of 0.028, for the first lag (and only

[95] If the stock prices follow a random walk then the current stock price in time point t will always be the best forecast for the stock price in t+1 since $p_{t+1} = \delta p_t + \varepsilon_{t+1}$ (in the case of a random walk: $\delta = 1$, ε_t follows a white noise process). So, if one is interested in the return Δp_t (or in our case the percentage return) the expected return can be deduced from the just quoted equation: $\Delta p_{t+1} = p_{t+1} - p_t = \varepsilon_{t+1}$. The expected return $E_t[\Delta p_{t+1}] = E_t[\varepsilon_{t+1}] = 0$ is purely stochastic (white noise) and therefore not predictable in a meaningful way. Therefore, the best prediction of the stock prices tomorrow is the stock price today.

for the first lag). The Q-statistic here tests the null hypothesis that there is no autocorrelation of the series $\%\Delta LLB_t$ up to the regarded order (see LJUNG AND BOX [1978, p.298]). This means that the stock return itself can be predicted to a certain extent by its own observable past, which is not in line with the already outlined market efficiency hypothesis. Also the risk, measured by the conditional variance, can be predicted using the past observed variables within the variance equation.

The main findings of the estimation equations for both banks, as shown in TABLE 50, are not sensitive to the assumption on the conditional distribution of the residual. As an alternative to the chosen normal distribution also student's t-distribution, which is sometimes preferred in the context of finance data, has been applied. The main findings about the significance, magnitude and sign of the coefficients, which have just been stated and which are outlined again at the end of this chapter, remain unchanged.

TABLE 51 summarizes and classifies the applied augmented amalGARCH(0,1,1)-model and relates this (in this application superior) approach to popular models that have been proposed in the literature:

	Different amalGARCH(p,q,s)-specifications			**Applied Augmentation**	
	Past Squared Residual: (p)	Past Conditional Variance: (q)	Past Squared Dependent Variable: (s)	Past Squared Independent Variables	Time Dummies: Data Theft, Financial Crisis
ENGLE [1982]: ARCH	✓				
WEISS [1984]	✓		✓	✓	
BOLLERSLEV [1986]: GARCH	✓	✓			
Augmented amalGARCH(0,1,1)		✓	✓	✓	✓
Invalid Results	☠	✓	☠	☠	✓

TABLE 51: Applied augmented amalGARCH(0,1,1) and other models within amalGARCH-group

The popular models included in the previous table can be integrated into the proposed amalGARCH-notation: The ARCH-model by ENGLE [1982] would be termed as amalGARCH(p,0,0), the specification of WEISS [1984] as amalGARCH(p,0,s) and the very popular GARCH-model by BOLLERSLEV [1986] as amalGARCH(p,q,0). The chosen model specification corresponds to an

amalGARCH(0,1,1) that was additionally augmented by a squared past independent variable ($\%\Delta SMI^2_{t-1}$) and the two time dummies capturing the financial crisis and the Zumwinkel-Affair. Applying all the possible components yielded invalid results (see footnote 94 and appendix 3.A.1.).

After the incorporation of the variance equation complementing the "ordinary" mean equation that accounts for the autoregressive heteroskedasticity (through the just outlined GARCH-approach) we observe that the squared residuals of the improved model are not autocorrelated anymore (they were autocorrelated in the model setup without the variance equation).

Correlogram of squared residuals ($\hat{u}_t^2$)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.005	0.005	0.0258	0.872
		2	-0.005	-0.005	0.0634	0.969
		3	-0.014	-0.013	0.2934	0.961
		4	0.005	0.005	0.3196	0.989
		5	0.010	0.010	0.4559	0.994
		6	-0.037	-0.038	2.2232	0.898
		7	-0.019	-0.019	2.6997	0.911
		8	0.000	0.000	2.6997	0.952
		9	0.005	0.003	2.7277	0.974
		10	0.014	0.013	2.9626	0.982

Correlogram of squared residuals ($\hat{u}_t^2$)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.031	0.031	1.1891	0.276
		2	-0.020	-0.021	1.7011	0.427
		3	-0.031	-0.030	2.9305	0.402
		4	0.019	0.020	3.3643	0.499
		5	0.053	0.050	6.8522	0.232
		6	0.045	0.041	9.3559	0.155
		7	0.014	0.014	9.5958	0.213
		8	-0.063	-0.060	14.635	0.067
		9	-0.021	-0.017	15.209	0.085
		10	-0.009	-0.014	15.322	0.121

FIGURE 50: Correlogram of squared residuals of the GARCH-model (%ΔVPB left side, %ΔLLB right side)

The (weak) significance at lag of 8 with a p-value of 0.067 has no economically intuitive interpretation and may be considered as an outlier. Such an outlier can be expected with the chance of 1 to 20 at each lag (so one outlier out of 20 is not uncommon), even if the series not auto-correlated at all (see CHATFIELD [2004, p.24]).

Plotting the graph with the estimated conditional standard deviations for $\%\Delta VPB$, one can clearly observe the higher level of volatility beginning with the Zumwinkel-Affair and the even higher risk during the financial crisis.

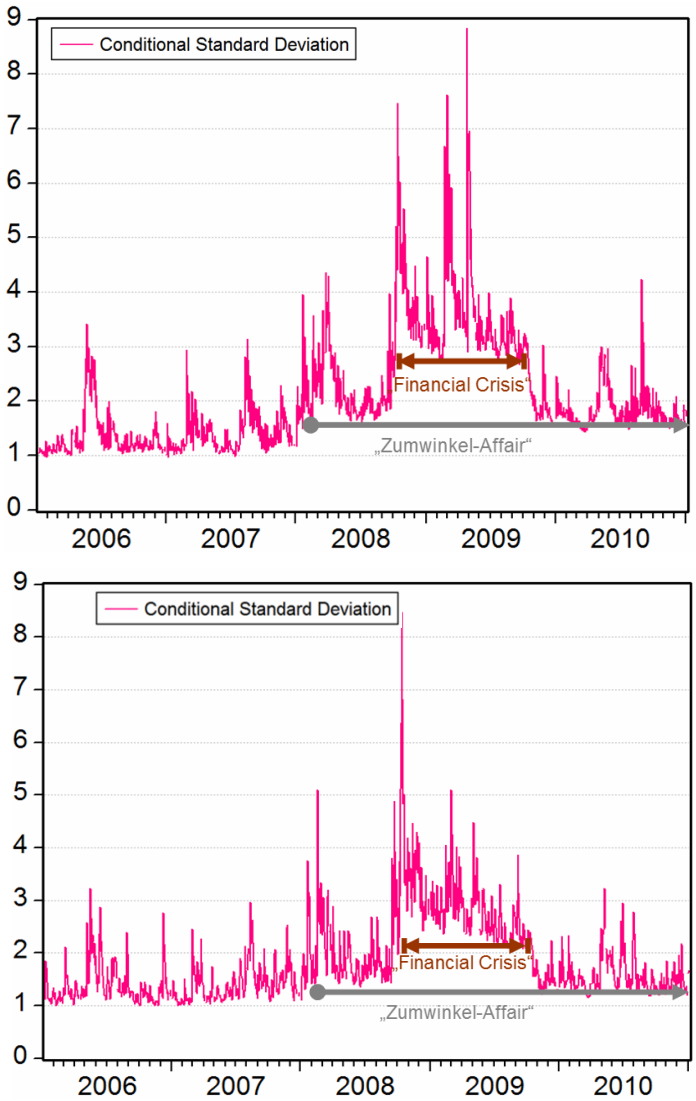

FIGURE 51: Estimated conditional standard deviation (%ΔVPB upper, %ΔLLB lower graph)

The conditional standard deviation plot (FIGURE 51) also reflects the already mentioned strong volatility clustering, meaning that risk is time-dependent (heteroskedasticity of both stocks). Plotting the graph with the estimated conditional standard deviations for %Δ*LLB*, it can be observed that volatility is slightly rising with the beginning of the "Zumwinkel-Affair", but considerably less compared to the conditional variance graph of %Δ*VPB*. This observation underlines the earlier findings from the estimation outputs: The financial crisis clearly had a cumulating impact on risk.

As an alternative, a GARCH(1,1) approach, which excludes the two variables $\%\Delta VPB(-1)^2$ or $\%\Delta LLB(-1)^2$ and $\%\Delta SMI(-1)^2$ from the variance equation but includes one past squared residual, has been estimated as well. The computed output results applying the GARCH(1,1)-model are analogous to the augmented amalGARCH(0,1,1)-model of the estimation output in TABLE 50 if we compare the estimates of the mean equation and the high significance of the two dummy variables in the variance equation (for further details and results see the appendix 3.A.1.).

The also popular GARCH-M specification (proposed by ENGLE, LILIEN AND ROBINS [1987]), which allows the conditional mean to depend directly on its own conditional variance, has also been estimated: The coefficient estimates of the independent variables in variance and mean equation were only slightly changed and the significance conclusions remained unchanged while the GARCH-M-component in the mean equation appeared to be insignificant. The analytical interpretation of this result could be that the stock prices are not directly dependent on risk in this case. The economic reasoning of a potential significance of the GARCH-M-component lies in the "value at risk"-argument: A (usually rather risk-avers) investor would desire better returns in order to compensate for higher risk, following usual finance theory such as Capital Asset Pricing Models.

So, it can be stated here that, in this context, the chosen unconventional modelling of the dependence of the conditional variance (on past observations instead of past residuals) beats the conventional forms after ENGLE [1982], BOLLERSLEV [1986] and also the less known specification by WEISS [1984], which also includes past observations but excludes lagged conditional variances. These conclusions rely on the consultation of the information criteria of AKAIKE [1974] and SCHWARZ [1978]

and also hold if the augmentation (financial crisis and data theft dummies) is skipped from the variance equation.[96]

It is important to refer to other specifications that have been executed for the estimation frame for both stocks in order to obtain a more general base to draw the central conclusions. These modifications shall be outlined in the following:

- *SPI (financial institutes) instead of SMI to capture market fluctuations*: As an alternative indicator for the market fluctuations a sub-index has also been used. This sub-index "SPI (financial institutes)" captures all financial institutes that are present at the Swiss Stock Exchange. However, the usage of this alternative indicator does not yield any changes worth mentioning. This result is not very surprising as visual and descriptive statistics suggest that both series SMI and SPI (financial institutes) are highly correlated.

- *TED Spread as alternative indicator for the financial crisis*: The TED spread is the calculated difference between the interest rates of the 3-months dollar-LIBOR (interbank loans) and the interest rates of 3-months U.S. treasury bills. It captures the observed credit risk and is therefore a good indicator for the trust in the financial market. As it turns out, the inclusion of the TED spread does not affect the sign or the significance of the dummy capturing the Zumwinkel-Affair. More detailed results are outlined in the appendix (3.A.2.).

- *Different lengths of the financial crisis dummy*: Along with the originally chosen time span used for the financial crisis time dummy other identifications of the relevant time span have been executed. The crucial finding that the

[96] It can be argued that it might not beneficial to gauge if a difference in information criterion's values between two (nested or non-nested) models is significant as this decision is already implicitly included in the criterion's choice. This is discussed by KUNST [2003]. Also, the fact that these information criteria somehow already incorporate a "likelihood ratio test choice" is mentioned in BURNHAM AND ANDERSON [2004] and STOICA, SELÉN AND LI [2004].

Zumwinkel-Affair had a significant (accumulating) effect on the risk of the banks' stock values is insensitive to the different lengths of the time span of the financial crisis dummy. The detailed results will be discussed in the appendix (3.A.3.).

- *Three time dummies*: Another alternation of the chosen setting is to have three time dummies for a better separation of short-run and long-run effects of the data theft. Hence, three dummies are introduced. The first one is from the beginning of the original data theft dummy in February 2008 (arrest of Zumwinkel) until the beginning of the original financial crisis dummy starting with the collapse of Lehman Brothers in October 2008. The second has the same time span as the original financial crisis dummy (October 2008 until October 2009) and the third one lasts from the end of the second time dummy until the end of the sample (beginning of 2011). It turns out that for both banks all the three dummies are insignificant in the mean equation, as could have been expected following the reasoning regarding the data theft and the financial crisis dummies discussed earlier. But the first two time dummies show high significance in the variance equation considering both banks. Also in this setting, it can be deduced that both events data theft and financial crisis have boosted volatility/risk of both banks' stock prices. Interestingly, the third dummy is only significant in the variance equation of the VPB.[97] So, while affecting both banks, the impact of the data theft seems to have vanished more rapidly for the LLB compared to the VPB.

One can conclude for both stock return series that the most important findings, such as the highly significant effect of the Zumwinkel-Affair on risk, do not change

[97] Wald-tests show that for VPB the difference between the third and the first time dummy in the variance equation is not significant (p-value of 0.1123), while the null of equality of these two dummies can be rejected in the case of LLB (p-value of 0.0324). The charts with the conditional variances over time are very similar to those in FIGURE 51.

across the various alternative specifications.[98] Also the estimation including the variables in differenced logarithms instead of percentage changes delivers similar results with the same conclusions, especially regarding the effects of primary interest.

As a crosscheck, the same estimations are also carried out for the Swiss banks Sarasin and Vontobel and compared with the results for Liechtenstein's banks. Of central concern is the crosscheck whether the magnifying effect of the data theft and the revelation of tax evaders (and also the following international pressure on Liechtenstein, the investors' insecurity and the following transformation process within the financial services sector in Liechtenstein) also had an effect for the Swiss banks. It turns out that no effect of the Zumwinkel Affair on the Swiss stocks' risk can be found: The coefficients are extremely small and not significant. Hence, the Zumwinkel Affair seems to have magnified the volatility of stock values of Liechtenstein's banks but not of the Swiss banks, which is intuitive and additionally supports the chosen model. In appendix 3.A.6., more specific interpretations of the estimations including the Swiss stock values are explained.

[98] This also holds for the inclusion of the stock returns of the LLB into the VPB-model and vice versa: The main results are not altered. The same remark applies if the financial crisis dummy is dropped. Also the inclusion of the interaction term $DATATHEFT*\%\Delta SMI$ does not affect the main results and the coefficient of the interaction term is not significant for both stock values' mean and variance equations.

3.3. Conclusions

During a time of very good performance in the middle of the first decade of this century the financial sector in Liechtenstein was flourishing, also in line with a general national and international economic expansion phase. But with the peak in 2007 and the ongoing start of the American sub-prime crisis the banking sector has faced rising pressure. The following financial crisis and the depicted "Zumwinkel-Affair" (affecting Liechtenstein's economy as a whole) was a huge challenge, maybe the most turbulent time in Liechtenstein's recent economic history and came along with a deep transformation process of its whole financial sector.

The main analytical findings of this empirical paper, which applied an augmented amalGARCH(0,1,1)-model, can be summed up as follows:

- *Accumulating effect of "Zumwinkel-Affair" on risk*: While the data theft dummy showed no significant impact on the average return performance of the two stock values' daily percentage changes there is striking evidence that the data theft and the affair had a deep impact on risk. The impact of the data theft time dummy on risk is significant for both stocks' conditional variance. However, the impact is considerably higher for the VPB-shares than for the LLB-shares. This main finding answering the main object of investigation was independent of alternative model specifications. These modified specifications are discussed in the main text and in particular in the appendix and consist for example of different specified GARCH-models, the inclusion of the TED spread (serving as proxy for market risk), the replacement of the SMI with the SPI (financial institutes) and differently chosen lengths of the financial crisis dummy. The magnifying effect of the data theft on risk is also insensitive to different assumptions on the conditional distribution of the residual. Yet, this impact seems to have vanished more rapidly in the case of LLB (compared to VPB). Also, along with a crosscheck, it has been found

that these conclusions regarding the data theft do not hold for the inspected Swiss banks Sarasin and Vontobel. There is no accumulating impact of the Zumwinkel Affair on the volatility of their stock prices detectable.

- *Financial crisis had an effect on risk*: Volatility (measured by the conditional variance) was directly affected by the financial crisis, which is indicated by the significant dummy. This holds for both stock return series. In addition, the significant effect of the financial crisis dummy and "Zumwinkel-Affair" dummy are both not really sensitive to changes in the chosen time period of the financial crisis time dummy considering the impact on risk.

- *Strong volatility clustering is present for both stocks*: The conditional risk is clearly time-dependent and the prediction of the risk is also subject to the estimated past risk. This has been shown in different tests indicating heteroskedasticity, by the significant lagged variables within the estimation of the variance equation and by the conditional variance graph and the strong autocorrelation of the generated conditional variance series.

- *Past (negative or positive) shocks boost volatility*: Both stocks' conditional variances are very sensitive to past shocks, which is expressed by the highly significant positive coefficients of the lagged squared observations of the percentage change of the SMI and the percentage change of the stock prices in the variance equation. This finding holds for both inspected stocks and is of course related to the statement about the volatility clustering made before.

- *Closely related to the market*: Both the performance and the volatility of the two stocks are closely linked to the general market fluctuations, the influence of the SMI is significant in the mean and in the variance equation.

- *No effect of Zumwinkel Affair and financial crisis on daily returns*: Surprisingly, the Zumwinkel Affair does not seem to have a strong effect on the stock returns of both banks (at least not when it comes to their daily percentage changes). Also the financial crisis had no additional total effect on the expected daily return as the financial crisis dummy is not significant in the mean equation due to the cancelling out effect already explained.[99] The financial crisis features a significant negative impact during the downturn period (fall 2008 until spring 2009) and a significant positive effect during the recovery period on the daily stock returns. It should be stated again that the included financial crisis dummy captures only the additional effect of the crisis beyond the connection of the SMI and the banks' stock prices. The financial crisis therefore had an effect in the downward period on both stocks' daily return beyond the impact already covered by the bad SMI-performance: During that period the VPB stock suffered even more from the crisis than the market and more than the LLB stock (which also suffered but not more severely than the market). Note that both the Zumwinkel Affair and the financial crisis dummy are highly significant within the variance equation, which was stated earlier.

- *Market efficiency*: While the daily VPB-stock returns feature no significant autocorrelation one can observe serial correlation of the LLB-stock returns (also expressed through the significant lagged dependent variable in the mean equation). However, the latter finding is not in line with the efficient market

[99] The following comment was already outlined earlier, but should be made here to summarize a few important points within the context of the financial crisis time dummy: The insignificance of its coefficient is not extremely surprising, as the recovery period was also covered by the time dummy, leading to a cancel out effect in total as the stock values are highly correlated with the SMI (which was used to define the financial crisis time span including downturn and recovery). This is well acceptable since the main emphasis is on the variance equation as the determinants of volatility are of primary interest. Moreover, the originally chosen time period for the financial crisis seems very plausible: The inclusion of some recovery into the chosen time period seems fairly reasonable as the financial crisis was surely not overcome by the reaching of the lowest trough of the Swiss Market Index in March 2009. During the recovery period afterwards, the market was still affected by high insecurity and volatility, both of which are of main interest here.

hypothesis, which states that a stock price return cannot at all be predicted using past observations, since all observable information has already been processed by the market and transferred into the stock prices.

In the course of this econometric project it has been shown that insecurity concerning the examined stock prices rose within the analysed time period, expressed by increasing risk (besides a strong volatility clustering). The effect of the "Zumwinkel-Affair" played an important role in this process. Within the chosen model this effect could be successfully separated from the market insecurity and other effects such as the financial crisis. It is not easy to judge how immediately this insecurity came from the data theft itself, but it is very reasonable to argue that it occurred from a combination of the already mentioned factors, such as the high political pressure, capital outflow, political reforms, and the transformation process within the financial sector (in this context it is important to keep in mind the comments made in the introduction[100]). Even though the causal relationships between these factors would be very interesting to investigate, it is almost impossible to analyse this question only in an econometric/statistical frame. To give answers other analytical tools should also be used. However, such considerations are not of central importance in this scientific context. The mentioned factors all contribute in a combined form to a common influence resulting in the effects shown in the econometric analysis. Along with the other included variables, the two introduced time dummies manage to capture the volatility clusters very well.

[100] It is very important to clarify that the aim of this paper is not to judge which was the main driving force behind the consequences of the data theft: The international pressure on Liechtenstein, the investors' insecurity, the capital outflows, or the tax information exchange agreements (and the causal relations between these factors). The emphasis is entirely on the empirical investigation whether the data theft had an impact on the stock price risk/performance and not what the driving forces behind this impact were, not to mention the question if any of these negative consequences were avoidable at all (or even reversible). This specific question "which one was the main impact?" might be easier to answer in a few years, maybe also leading to the conclusion that some factors, while with a negative impact in the short-run, might exhibit a positive effect in the long-run on the banks' performance and the stock prices (factors such as the transformation process or the tax information exchange agreements).

It would be very interesting to incorporate other sources of influence on the performance and the risk of the investigated stock series. However, as the model takes advantage of the daily availability of stock data, which enables a better capture of short-run dynamics, it is complicating to find other potentially influential data that are also available at such a high frequency.

Apart from the analytical conclusions arising from these empirical investigations there are also other (econometrically) important features of the applied setup: There exists convincing evidence that the chosen augmented amalGARCH(0,1,1)-model[101] is superior in this application to the popular, ordinary and "non-augmented" GARCH(1,1)-approach, which would be equivalent to the term amalGARCH(1,1,0) without any additional explanatory/control variables in the variance equation. It is also superior to the augmented GARCH(1,1)-specification without the additional squared lagged variables, albeit with similar coefficient estimates considering the two variables of interest (namely the two time dummies). As shown, the proposed setting within this contribution therefore outperforms here the widely-applied specifications after ENGLE [1982] and BOLLERSLEV [1986] that both do not include past observations in the variance equation and also the less known specification after WEISS [1984] which does include them but does not incorporate past conditional variances. This econometric finding could not have been expected in the first place since it is an exceptional case, but supports the chosen approach beyond its analytical advantages. Additionally, the applied specification enables a better understanding via which channels past shocks translate into rising volatility of the stock prices compared to the widely applied settings by the prementioned authors only incorporating conventional components into the variance equation (the past conditional variances and undefined past shocks via the past squared residuals). The interesting past shocks are made visible in the proposed augmented

[101] As already mentioned, the chosen "unconventional" and augmented amalGARCH (0,1,1)-model contains squared past observations of the SMI-value's daily percentage change and the bank's stock returns plus the two time dummies for the "Zumwinkel-Affair" and the financial crisis in the variance equation while the squared lagged residuals originating from the mean equation are dropped.

amalGARCH(0,1,1)-setting by introducing additional explanatory variables such as the past squared returns of the particular stock value and the squared percentage changes of the whole market index and also potential shocks on either or both of them.

Also, in the course of this project, a new term classifying popular specifications of the modelling of the conditional variance within one group could be introduced. This term, amalGARCH(p,q,s), includes possible amalgams of the approaches of ENGLE [1982], WEISS [1984] and BOLLERSLEV [1986]/TAYLOR [1986].

3.A. Appendix

3.A.1. Alternative amalGARCH-Approaches

As already mentioned and explained in sections 3.2. and 3.3., a different GARCH-approach has been applied as an alternative to the augmented amalGARCH(0,1,1)-specification with lagged squared observations of the stock prices and of the SMI ($\%\Delta VPB(-1)^2$ or $\%\Delta LLB(-1)^2$ and $\%\Delta SMI(-1)^2$). Also, ARCH-models after ENGLE [1982] (amalGARCH(p,0,0) that only includes past residuals) have been estimated but then skipped as they were inferior to the GARCH-specifications after BOLLERSLEV [1986]).

The relevant results appear insensitive to the distinction between the augmented amalGARCH(0,1,1) or the augmented GARCH(1,1) specification without lagged squared observations: The evaluation of the effects of the "Zumwinkel-Affair" and the financial crisis on performance and risk, which was the main objective of investigation in this paper, remains unaltered. The statement made in footnote 94 can be repeated here, as its holds for the estimation process of $\%\Delta VPB$ and $\%\Delta LLB$: It seems that it is problematic in this case to include past observations (of variables from the mean equation) <u>and</u> past squared residuals (of the mean equation) into the variance equation. Higher GARCH-orders in the original augmented variance equation (especially of past squared residuals) generate unacceptably many insignificant estimates and even negative coefficients (which is invalid in the context of GARCH-models). Dropping the lagged variables from the variance equation removes these problems. TABLE 52 and TABLE 53, where percentage differences of variables are prefixed with "PD_", show that the two alternative approaches generate analogous results.

Dependent Variable: PD_VPB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 01/27/11 Time: 04:50
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 42 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*GARCH(-1) + C(7)*PD_VPB(-1)^2 + C(8)
*PD_SMI(-1)^2 + C(9)*FINANCIALCRISIS + C(10)*DATATHEFT

	Coefficient	Std. Error	z-Statistic	Prob.
PD_VPB(-1)	-0.010239	0.031656	-0.323430	0.7464
PD_SMI	0.594137	0.042882	13.85515	0.0000
FINANCIALCRISIS	-0.019577	0.261002	-0.075007	0.9402
DATATHEFT	-0.017935	0.091245	-0.196553	0.8442
Variance Equation				
C	0.307309	0.084682	3.628972	0.0003
GARCH(-1)	0.645165	0.064753	9.963490	0.0000
PD_VPB(-1)^2	0.108462	0.022197	4.886225	0.0000
PD_SMI(-1)^2	0.169894	0.041518	4.092028	0.0000
FINANCIALCRISIS	1.982111	0.497751	3.982132	0.0001
DATATHEFT	0.454955	0.121831	3.734311	0.0002

R-squared	0.125485	Mean dependent var	-0.022798
Adjusted R-squared	0.119169	S.D. dependent var	2.460821
S.E. of regression	2.309545	Akaike info criterion	4.147858
Sum squared resid	6646.159	Schwarz criterion	4.188747
Log likelihood	-2594.855	Durbin-Watson stat	1.926045

Dependent Variable: PD_VPB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 01/27/11 Time: 05:29
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 27 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1) + C(8)
*FINANCIALCRISIS + C(9)*DATATHEFT

	Coefficient	Std. Error	z-Statistic	Prob.
PD_VPB(-1)	-0.010846	0.029363	-0.369357	0.7119
PD_SMI	0.565213	0.037601	15.03192	0.0000
FINANCIALCRISIS	0.193831	0.248199	0.780952	0.4348
DATATHEFT	-0.042140	0.093559	-0.450414	0.6524
Variance Equation				
C	0.367928	0.094571	3.890492	0.0001
RESID(-1)^2	0.157713	0.028247	5.583388	0.0000
GARCH(-1)	0.658494	0.061456	10.71481	0.0000
FINANCIALCRISIS	1.884990	0.492926	3.824081	0.0001
DATATHEFT	0.478630	0.125134	3.824944	0.0001

R-squared	0.122376	Mean dependent var	-0.022798
Adjusted R-squared	0.116745	S.D. dependent var	2.460821
S.E. of regression	2.312719	Akaike info criterion	4.169544
Sum squared resid	6669.791	Schwarz criterion	4.206344
Log likelihood	-2609.474	Durbin-Watson stat	1.918032

TABLE 52: Estimation outputs of the augmented GARCH(0,1)-model and alternative GARCH(1,1)-model (%ΔVPB)

The significance structure of the variables within the mean and the variance equation and the estimated coefficients remains nearly unchanged (same signs and comparable magnitude).

Also the patterns of the estimated conditional standard deviation shown in FIGURE 52 and gained from the variance equation are comparable across the two approaches:

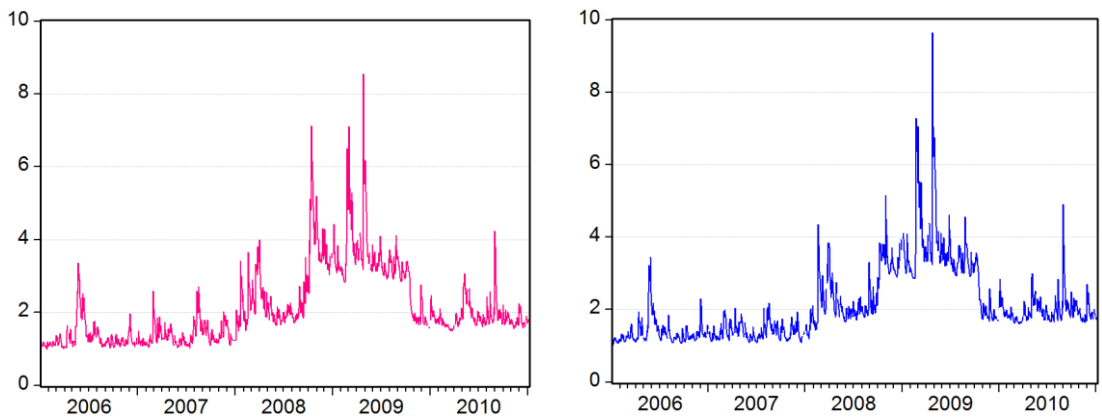

FIGURE 52: Conditional standard deviation (%ΔVPB) applying GARCH(0,1)-model with squared past observations (left graph) and GARCH(1,1)-model without (right graph)

Both estimated conditional standard deviations show similarly timed volatility outbursts, especially during the financial crisis (end of 2008 until end of 2009) and in the beginning of the "Zumwinkel-Affair" (in the beginning of 2008). Both graphs feature a strong and similar volatility clustering.

Dependent Variable: PD_LLB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 01/27/11 Time: 05:25
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 17 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*GARCH(-1) + C(7)*PD_LLB(-1)^2 + C(8)
*PD_SMI(-1)^2 + C(9)*FINANCIALCRISIS + C(10)*DATATHEFT

	Coefficient	Std. Error	z-Statistic	Prob.
PD_LLB(-1)	-0.086890	0.032827	-2.646936	0.0081
PD_SMI	0.416952	0.039077	10.67009	0.0000
FINANCIALCRISIS	0.078399	0.188691	0.415490	0.6778
DATATHEFT	-0.010578	0.074336	-0.142297	0.8868
Variance Equation				
C	0.421693	0.092447	4.561443	0.0000
GARCH(-1)	0.533147	0.060467	8.817209	0.0000
PD_LLB(-1)^2	0.163867	0.022305	7.346628	0.0000
PD_SMI(-1)^2	0.244959	0.050403	4.859966	0.0000
FINANCIALCRISIS	1.224834	0.383799	3.191338	0.0014
DATATHEFT	0.161700	0.076432	2.115617	0.0344

R-squared	0.077355	Mean dependent var	0.014775
Adjusted R-squared	0.070691	S.D. dependent var	2.047996
S.E. of regression	1.974282	Akaike info criterion	3.949250
Sum squared resid	4856.648	Schwarz criterion	3.990139
Log likelihood	-2470.129	Durbin-Watson stat	2.001918

Dependent Variable: PD_LLB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 01/27/11 Time: 05:28
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 19 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1) + C(8)
*FINANCIALCRISIS + C(9)*DATATHEFT

	Coefficient	Std. Error	z-Statistic	Prob.
PD_LLB(-1)	-0.081035	0.030009	-2.700302	0.0069
PD_SMI	0.428196	0.031033	13.79792	0.0000
FINANCIALCRISIS	0.037523	0.185392	0.202399	0.8396
DATATHEFT	0.004081	0.071469	0.057102	0.9545
Variance Equation				
C	0.570370	0.098710	5.778220	0.0000
RESID(-1)^2	0.225942	0.024068	9.387582	0.0000
GARCH(-1)	0.531451	0.053820	9.874635	0.0000
FINANCIALCRISIS	1.548949	0.388522	3.986768	0.0001
DATATHEFT	0.182107	0.076537	2.379317	0.0173

R-squared	0.077565	Mean dependent var	0.014775
Adjusted R-squared	0.071647	S.D. dependent var	2.047996
S.E. of regression	1.973266	Akaike info criterion	3.969404
Sum squared resid	4855.544	Schwarz criterion	4.006205
Log likelihood	-2483.786	Durbin-Watson stat	2.014471

TABLE 53: Estimation outputs of the augmented GARCH (0,1)-model and alternative GARCH(1,1)-model (%ΔLLB)

The former findings from inspecting the amalGARCH(1,1,0)-regression of %Δ*VPB* also hold for the regression of %Δ*LLB*. The significance of the variables is unchanged with same signs and comparable magnitude of the coefficients. Also the pattern of the estimated conditional standard deviations shown in FIGURE 53 and gained from the variance equation is comparable for the two model approaches:

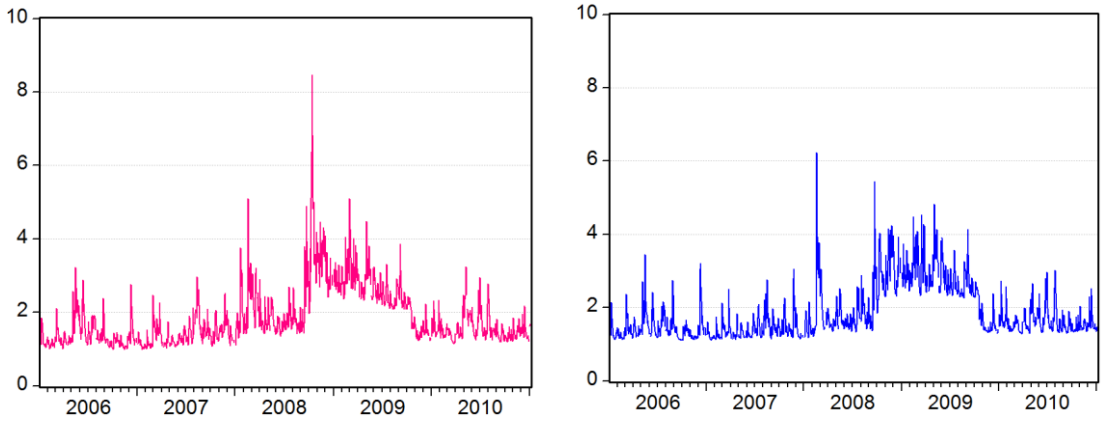

FIGURE 53: Conditional standard deviation (%ΔLLB) applying GARCH(0,1)-model with squared past observations (left graph) and GARCH(1,1)-model without (right graph)

As already stated in the main section of this text, also an ordinary popular benchmark model has been estimated: The "non-augmented" pure GARCH(1,1), which is equivalent to non-augmented amalGARCH(1,1,0), whose output is listed in TABLE 54.

Dependent Variable: PD_VPB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 02/06/11 Time: 03:38
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 31 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
PD_VPB(-1)	-0.008312	0.027461	-0.302686	0.7621
PD_SMI	0.561171	0.039259	14.29402	0.0000
FINANCIALCRISIS	0.132898	0.176759	0.751863	0.4521
DATATHEFT	-0.022319	0.081462	-0.273986	0.7841
Variance Equation				
C	0.047823	0.012418	3.851020	0.0001
RESID(-1)^2	0.093660	0.009938	9.424133	0.0000
GARCH(-1)	0.904649	0.007291	124.0696	0.0000

R-squared	0.122964	Mean dependent var	-0.022798
Adjusted R-squared	0.118751	S.D. dependent var	2.460821
S.E. of regression	2.310092	Akaike info criterion	4.194759
Sum squared resid	6665.321	Schwarz criterion	4.223381
Log likelihood	-2627.309	Durbin-Watson stat	1.924071

Dependent Variable: PD_LLB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 02/06/11 Time: 03:28
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 16 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
PD_LLB(-1)	-0.079928	0.028993	-2.756821	0.0058
PD_SMI	0.440562	0.029036	15.17321	0.0000
FINANCIALCRISIS	0.013665	0.130250	0.104917	0.9164
DATATHEFT	0.009709	0.067526	0.143782	0.8857
Variance Equation				
C	0.265468	0.039524	6.716619	0.0000
RESID(-1)^2	0.190966	0.017740	10.76456	0.0000
GARCH(-1)	0.749135	0.021126	35.46105	0.0000

R-squared	0.077360	Mean dependent var	0.014775
Adjusted R-squared	0.072928	S.D. dependent var	2.047996
S.E. of regression	1.971904	Akaike info criterion	4.000645
Sum squared resid	4856.621	Schwarz criterion	4.029267
Log likelihood	-2505.405	Durbin-Watson stat	2.017996

TABLE 54: Estimation output of a pure GARCH (1,1)-approach as benchmark model applied for %ΔLLB (right table) and %ΔVPB (left table)

The highly significant coefficients of the explanatory/control variables and the better information criteria (as shown in TABLE 52, TABLE 53, TABLE 54, TABLE 55) indicate that the chosen augmented amalGARCH(0,1,1)-model is an improvement to the more parsimonious specifications.

FIGURE 54 shows the estimated conditional standard deviations of the stock returns of the two banks applying the ordinary GARCH(1,1)-benchmark model. In both graphs the beginning of the "Zumwinkel-Affair" in the first half of 2008 and the financial crisis (especially during 2009) are visible through higher volatility.

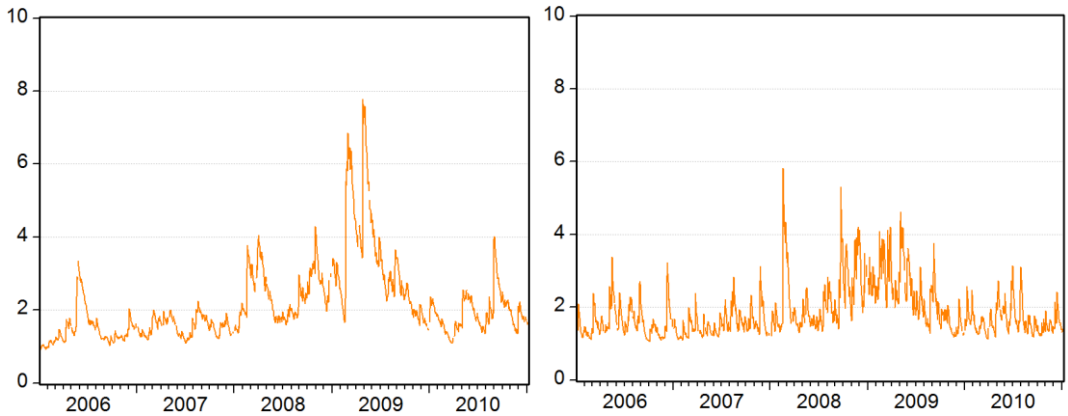

FIGURE 54: Conditional standard deviation applying a "non-augmented" GARCH(1,1)-model for %ΔVPB (left graph) and %ΔLLB (right graph)

TABLE 55 exhibits an overview of the described competing models with the different specification of the variance equation. It features the various GARCH-specifications which have just been outlined. It is visible that the coefficient estimates of the important variables are not very different considering the sign, significance and magnitude of the coefficients.

	Dependent Variable					
	$\%\Delta VPB_t$			$\%\Delta LLB_t$		
(Conditional) Mean Equation						
$\%\Delta VPB_{t-1}$	-0.0102	-0.0108	-0.0083			
$\%\Delta LLB_{t-1}$				-0.0869***	-0.0810***	-0.0799***
$\%\Delta SMI_t$	0.5941***	0.5652***	0.5612***	0.4170***	0.4282***	0.4406***
Financial Crisis	-0.0196	0.1938	0.1329	0.0784	0.0375	0.0137
Data Theft	-0.0179	-0.0421	-0.0223	-0.0106	0.0041	0.0097
(Conditional) Variance Equation						
Constant	0.3073***	0.3679***	0.0478***	0.4217***	0.5704***	0.2655***
$ARCH(1)^{1)}: \hat{u}_{t-1}^2$		0.1577***	0.0937***		0.2259***	0.1910***
$GARCH(1)^{2)}: h_{t-1}$	0.6452***	0.6585***	0.9046***	0.5331***	0.5315***	0.7491***
$\%\Delta VPB_{t-1}^2$	0.1085***					
$\%\Delta LLB_{t-1}^2$				0.1639***		
$\%\Delta SMI_{t-1}^2$	0.1699***			0.2450***		
Financial Crisis	1.9821***	1.8850***		1.2248***	1.5489***	
Data Theft	0.4550***	0.4786***		0.1617**	0.1821**	
Measures of Fit						
R^2	0.1255	0.1224	0.1230	0.0774	0.0776	0.0774
Adjusted R^2	0.1192	0.1167	0.1188	0.0707	0.0716	0.0729
Akaike Info Criterion	4.1479	4.1695	4.1948	3.9493	3.9694	4.0006
Schwarz Info Criterion	4.1887	4.2063	4.2234	3.9901	4.0062	4.0293

1) Past squared residual from the mean equation (past shocks).
2) Lagged conditional variance (serial time dependency of risk).
The magnitude of the relevant p-values are marked with stars and therefore reflects the significance of the respective parameter (*: p-value ≤ 0.10 and > 0.05, **: p-value ≤ 0.05 and > 0.01, ***: p-value ≤ 0.01). The p-value denotes the lowest significance level at which the null hypothesis (of insignificance in this case) could be rejected regarding the regressor's t-value (which is here the estimated coefficient of the regressor divided by the estimated standard error of the coefficient).
See sections 2.2. and 2.3. for the theoretical equation setup and estimation results of the main GARCH-models.

TABLE 55: Competing models with different specifications of the variance equation

It also turns out that the applied setting, the augmented amalGARCH(0,1,1,), outperforms the other two benchmarking approaches in this application. Note that footnote 96 also applies here.

3.A.2. Inclusion of TED Spread

One could also include the TED spread as an alternative proxy for the financial crisis (apart from the financial crisis time dummy). The TED ("treasury bill euro difference dollar") spread is the calculated difference between the interest rates of the 3-months dollar-LIBOR (interbank loans) and the interest rates of 3-months

U.S. treasury bills. The spread is expressed in base points: So if, for example, the LIBOR's interest rate is one percentage point higher (e.g. 6%) than the treasuries' interest rate (e.g. 5%), then the TED spread is 100. The TED spread captures the observed credit risk and is therefore a good indicator for the trust in the financial market. As it turns out, the inclusion of the TED spread does not affect the sign or the significance of the dummy capturing the Zumwinkel-Affair.

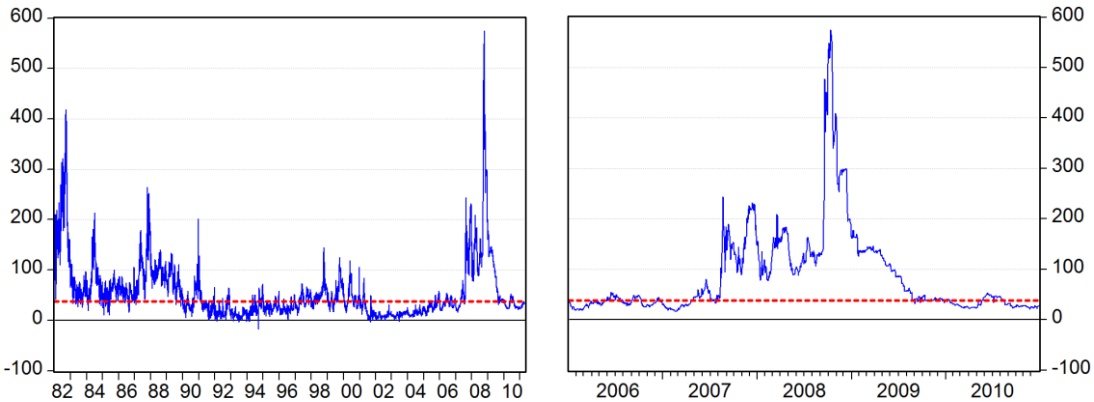

FIGURE 55: The TED spread (blue line) and its historical median (red dotted line)

FIGURE 55 shows the TED spread since 1982 (left graph) and in more detail covering the investigated time period (right graph). Different recessions or shocks are visibly expressed by the TED spread time plot: The second oil shock around 1981/1982, the Black Monday in 1987, the Iraq War in 1990, the Asian Crisis by the end of the 90th century and the turbulences in 2001. But most importantly, the outburst reflects the recent financial crisis very strikingly.

Carrying out the estimations including the daily percentage change of the TED spread it can be observed in TABLE 56 that the clear significant effects of the financial crisis and the Zumwinkel Affair within the variance equation remain untouched.[102] If the output tables showing the main models in section 3.2. and 3.3. are consulted it is evident that also the other important variables are unaffected

[102] The sample had to be slightly adjusted as the trading days in the US sometimes differ from the trading days in Switzerland. Also, daily percentage changes of the TED spread have been calculated and used in the estimations because of analytical reasons and since various tests indicate that the TED spread contains a unit root and therefore follows a random walk.

inspecting the sign and significance of their coefficients. But it should be noted that the percentage change of the TED spread is significant within the mean equation of the LLB-stocks and slightly significant within the variance equation of the VPB-stocks. At first sight it is not easy to identify particular reasons why the TED spread seems to have an impact on the return of the LLB-stock in mean and on the risk of the VPB-stock, but not directly on the level of the returns of VPB and not on risk of LLB. This will not be examined here in further detail but would sure be worth being investigated in future research.

	Dependent Variable					
	$\%\Delta VPB_t$			$\%\Delta LLB_t$		
(Conditional) Mean Equation						
$\%\Delta VPB_{t-1}$	0.0044	-0.0065	-0.0056			
$\%\Delta LLB_{t-1}$				-0.0894***	-0.0868***	-0.0869***
$\%\Delta SMI_t$	0.5684***	0.5680***	0.5683***	0.3984***	0.4087***	0.4072***
Financial Crisis		-0.0014	0.0183		0.0396	0.0839
$\%\Delta TED\ Spread_t$	-0.0023	-0.0036	-0.0041	-0.0110**	-0.0125**	-0.0152***
$Financial\ Crisis * \%\Delta TED\ Spread_t$			0.0146			0.0606
Data Theft	-0.0067	-0.0061	-0.0067	0.0047	-0.0181	-0.0179
(Conditional) Variance Equation						
Constant	0.0718***	0.2497***	0.2917***	0.2215***	0.3936***	0.3975***
$GARCH(1)^{1)} : h_{t-1}$	0.8440***	0.6946***	0.6515***	0.6934***	0.5918***	0.5903***
$\%\Delta VPB^2_{t-1}$	0.0897***	0.0986***	0.1100***			
$\%\Delta LLB^2_{t-1}$				0.1329***	0.1265***	0.1267***
$\%\Delta SMI^2_{t-1}$	0.0754***	0.1353***	0.1532***	0.1765***	0.1827***	0.1806***
Financial Crisis		1.7046***	1.8318***		1.1303***	1.0585***
$\%\Delta TED\ Spread_t$	0.0105*	0.0181**	0.0185**	-0.0008	0.0049	0.0050
$Financial\ Crisis * \%\Delta TED\ Spread_t$			-0.1799			-0.0368
Data Theft	0.1737***	0.3677***	0.4299***	0.1842***	0.1623**	0.1631**
Measures of Fit						
R^2	0.1163	0.1156	0.1161	0.0717	0.0716	0.0792
Adjusted R^2	0.1097	0.1075	0.1065	0.0648	0.0631	0.0693
Akaike Info Criterion	4.1500	4.1279	4.1302	3.9451	3.9300	3.9293
Schwarz Info Criterion	4.1920	4.1784	4.1890	3.9871	3.9804	3.9881

[1)] Lagged conditional variance (serial time dependency of risk)
The magnitude of the relevant p-values are marked with stars and therefore reflects the significance of the respective parameter (*: p-value ≤ 0.10 and > 0.05, **: p-value ≤ 0.05 and > 0.01, ***: p-value ≤ 0.01). The p-value denotes the lowest significance level at which the null hypothesis (of insignificance in this case) could be rejected regarding the regressor's t-value (which is here the estimated coefficient of the regressor divided by the estimated standard error of the coefficient).
See sections 2.2. and 2.3. for the theoretical equation setup and estimation results of the main GARCH-models.

TABLE 56: Competing models including the TED spread's percentage change

3.A.3. Alternative Time Spans of Financial Crisis

As already stated in the main text, it is useful to allow for different lengths of the chosen time period of the financial crisis captured by the financial time dummy. In chapter 2.1. the motivation for the original choice of the time span of the two time dummies is already outlined. Along with the original time span (labelled with "Financial Crisis") from October 6th (2008) to October 16th (2009) with the SMI as reference two other time spans have been applied: As second time span covered a shorter period is applied and just covers the sharp decline from October 6th (2008) until March 9th (2008), again with the SMI as reference for the downturn. A longer period, which now relies on the TED spread[103] as reference, has also been considered. Apart from the visual detection of the visible beginning of the financial crisis by inspecting the TED chart the median of the TED spread serves as a useful threshold for a more precise detection of the timing of the financial crisis (see FIGURE 55). The TED spread exceeds the median of 38 on April 25th (2007) and does not score below 38 until August 24th (2009). This time span has been chosen to set the length for the longest period of the financial crisis time dummy (labelled in FIGURE 56 as "Financial Crisis (long)"). The three different time periods chosen are marked in the next figure.

All the relevant estimation results are listed in the output of TABLE 57 and are summarized in the following. The crucial finding that the Zumwinkel-Affair had a significant (accumulating) effect on the risk of the banks' stock values is insensitive to the different lengths of the time span of the financial crisis dummy. The effect of the financial crisis on risk vanishes in the longest time period specification of the financial crisis time dummy. This is the case within the variance equation of both stock values.

[103] The explanation and the plotted time series of the TED spread can be found in section 3.A.2. of the appendix.

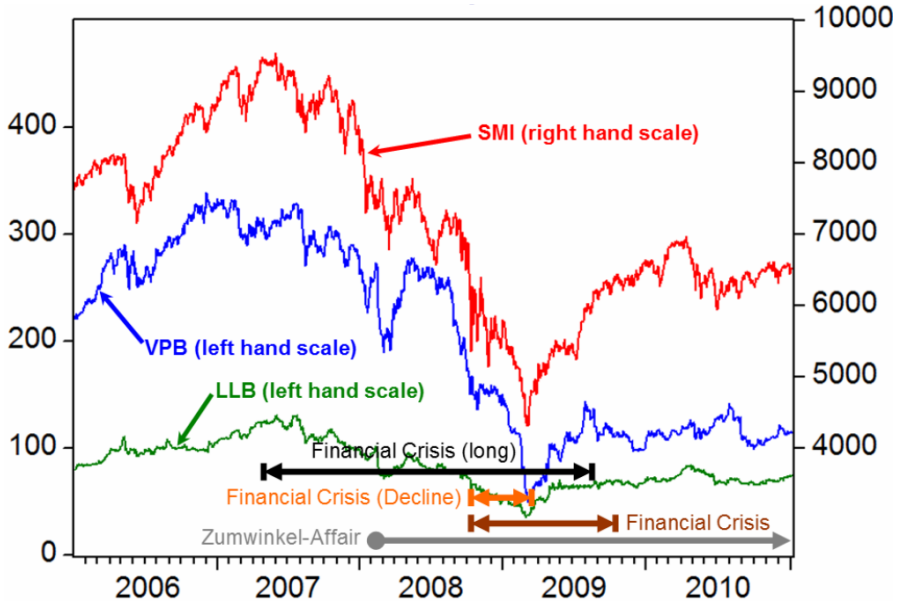

FIGURE 56: Different specifications of the financial crisis time dummy's length

There is an additional observation that only for the shortest period (the downturn phase without recovery) the financial crisis dummy shows significance in the mean equation of the VPB-stocks, while it shows no significance within the mean equation of the LLB-stock for all various lengths of the financial crisis dummy. If the SMI is removed from the mean equation then the financial crisis dummy becomes also significant in the equation with the LLB-stock as dependent variable. So, the financial crisis had no impact on the LLB- and no impact on the VPB-stock average returns that was worse compared to the impact on the market (not in the downward phase and not if the recovery period is included into the time definition of the financial crisis). Second, they only suffered from the financial crisis during the downturn phase. The LLB-stock was hit to a very similar extent as the market, the VPB-stock performed even worse than the market.

	Dependent Variable					
	$\%\Delta VPB_t$			$\%\Delta LLB_t$		
(Conditional) Mean Equation						
$\%\Delta VPB_{t-1}$	-0.0102	-0.0022	0.0031			
$\%\Delta LLB_{t-1}$				-0.0869***	-0.0895***	-0.0904***
$\%\Delta SMI_t$	0.5941***	0.5849***	0.5931***	0.4170***	0.3985***	0.4028***
Financial Crisis	-0.0196			0.0784		
Financial Crisis (Short)		-0.8684**			-0.5173	
Financial Crisis (Long)			-0.0392			-0.0246
Data Theft	-0.0179	0.0310	-0.0106	-0.0106	0.0461	0.0262
(Conditional) Variance Equation						
Constant	0.3073***	0.0585***	0.0692***	0.4217***	0.3342***	0.2607***
$GARCH(1)^{1)}: h_{t-1}$	0.6452***	0.8836***	0.8569***	0.5331***	0.5826***	0.6218***
$\%\Delta VPB^2_{t-1}$	0.1085***	0.0633***	0.0810***			
$\%\Delta LLB^2_{t-1}$				0.1639***	0.1714***	0.1696***
$\%\Delta SMI^2_{t-1}$	0.1699***	0.0588***	0.0604***	0.2450***	0.2360***	0.2215***
Financial Crisis	1.9821***			1.2248***		
Financial Crisis (Short)		0.2207**			1.2306*	
Financial Crisis (Long)			0.0332			0.0960
Data Theft	0.4550***	0.1091***	0.1565***	0.1617**	0.2413***	0.2096***
Measures of Fit						
R^2	0.1255	0.1365	0.1267	0.0774	0.0818	0.0771
Adjusted R^2	0.1192	0.1303	0.1204	0.0707	0.0752	0.0704
Akaike Info Criterion	4.1479	4.1644	4.1712	3.9493	3.9595	3.9663
Schwarz Info Criterion	4.1887	4.2053	4.2121	3.9901	4.0004	4.0072

[1)] Lagged conditional variance (serial time dependency of risk).
The magnitude of the relevant p-values are marked with stars and therefore reflects the significance of the respective parameter (*: p-value ≤ 0.10 and > 0.05, **: p-value ≤ 0.05 and > 0.01, ***: p-value ≤ 0.01). The p-value denotes the lowest significance level at which the null hypothesis (of insignificance in this case) could be rejected regarding the regressor's t-value (which is here the estimated coefficient of the regressor divided by the estimated standard error of the coefficient).
See sections 2.2. and 2.3. for the theoretical equation setup and estimation results of the main GARCH-models.

TABLE 57: Competing models with different time periods of the financial crisis dummy

It should be stated again that the SMI-variable also contains the impact of the financial crisis on the whole market to which the banks' stocks are heavily linked and correlated. The financial crisis dummy in the mean equation therefore measures whether the impact was stronger or less strong compared to the market.

The originally chosen time period appears to be the most appropriate as the emphasis should be on the most suitable time period concerning the variance equation which is of main interest in this contribution's analysis. Also, the information criteria are optimized in that setting regarding the length of the financial crisis time dummy (note that the sample is always the same). The longest period

seems too long in this context. The recovery should also be included as it was still a very insecure period affecting returns and especially volatility on the financial markets[104].

3.A.4. Detection of ARCH-Effects

As already argued in the main text, both investigated series (%Δ*VPB* and %Δ*LLB*) seem to feature autoregressive heteroskedasticity. These findings of the descriptive analysis shall be underlined in a more elaborate manner in the following. First, the series of the VPB-stock is investigated: In the left graph of FIGURE 57 we can recognize that the occurrence of extreme values is more likely compared to the normal quantile ("heavy tail property") while the right graph shows the higher kurtosis of the series compared to the normal distribution.

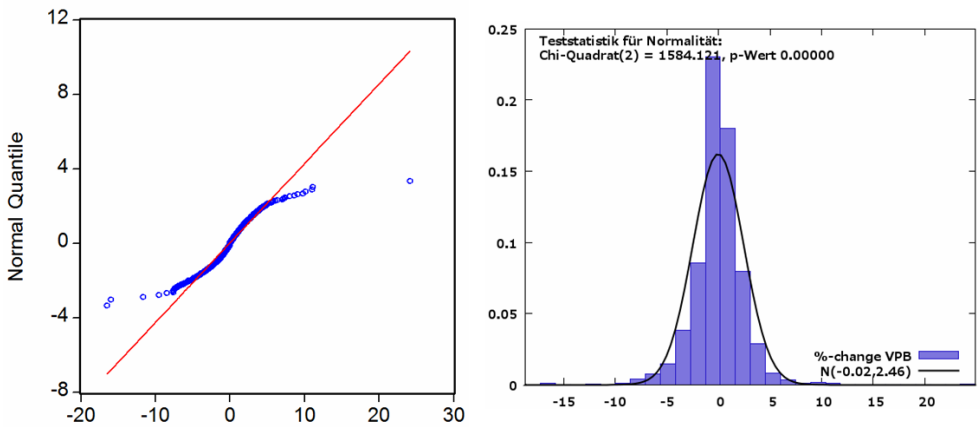

FIGURE 57: Comparison sample distribution/quantile with normal distribution/quantile (%ΔVPB)

The setup of the estimation has already been introduced (in section 3.1.). Carrying out the estimation of the mean equation (in a first step without GARCH-modelling) delivers already in an early stage important conclusions that highlight the econometric suitability of the inclusion of a GARCH-structure: The regression of

[104] The high level of stock prices in 2007 can be seen as "overshooting" rather than being a good "average benchmark".

the daily percentage difference of the VPB-stock prices (denoted as PD_VPB) yields autocorrelated squared residuals. On the other hand, the non-squared residuals show no clearly significant serial correlation. Also the autocorrelation function of the series $\%\Delta VPB$ itself unveils no autocorrelation, while the autocorrelation function of $\%\Delta VPB^2$ shows significant autocorrelation and therefore heteroskedastic characteristics. Both is shown in TABLE 58. Positive serial dependency of the residuals‘ second moments indicates that the variance is not constant over time (heteroskedasticity, volatility clustering).

Dependent Variable: PD_VPB
Method: Least Squares
Date: 01/27/11 Time: 04:56
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PD_VPB(-1)	0.043607	0.026374	1.653386	0.0985
PD_SMI	0.652914	0.048323	13.51158	0.0000
FINANCIALCRISIS	-0.019899	0.178008	-0.111785	0.9110
DATATHEFT	-0.061710	0.106261	-0.580735	0.5615

R-squared	0.129675	Mean dependent var	-0.022798
Adjusted R-squared	0.127590	S.D. dependent var	2.460821
S.E. of regression	2.298478	Akaike info criterion	4.505551
Sum squared resid	6614.315	Schwarz criterion	4.521906
Log likelihood	-2825.486	Durbin-Watson stat	2.042928

Correlogram of squared residuals ($\hat{u}_t^2$)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.134	0.134	22.751	0.000
		2	0.085	0.068	31.922	0.000
		3	0.130	0.113	53.382	0.000
		4	0.133	0.101	75.560	0.000
		5	0.208	0.173	130.04	0.000
		6	0.030	-0.038	131.16	0.000
		7	0.048	0.004	134.04	0.000
		8	0.081	0.026	142.35	0.000
		9	0.076	0.028	149.69	0.000
		10	0.101	0.052	162.52	0.000

TABLE 58: Results of “ordinary” estimation (without GARCH-specification) and correlogram of squared residuals

An ARCH-test as proposed by ENGLE [1982] is carried out to verify the presence of autoregressive heteroskedasticity in a more formal way. Both the Lagrange Multiplier (LM) test and the F-test are computed using an auxiliary regression of the “ordinary” model’s squared residual against squared lagged[105] residuals plus a constant.

[105] The lag length has been chosen as subject to the AKAIKE [1974] and the SCHWARZ [1978] information criteria, but it was found that the clear test results were insensitive to varying lag lengths anyway.

Dependent Variable: PD_VPB
Method: Least Squares
Date: 01/27/11 Time: 04:56
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PD_VPB(-1)	0.043607	0.026374	1.653386	0.0985
PD_SMI	0.652914	0.048323	13.51158	0.0000
FINANCIALCRISIS	-0.019899	0.178008	-0.111785	0.9110
DATATHEFT	-0.061710	0.106261	-0.580735	0.5615

R-squared	0.129675	Mean dependent var	-0.022798
Adjusted R-squared	0.127590	S.D. dependent var	2.460821
S.E. of regression	2.298478	Akaike info criterion	4.505551
Sum squared resid	6614.315	Schwarz criterion	4.521906
Log likelihood	-2825.486	Durbin-Watson stat	2.042928

ARCH Test:

F-statistic	19.78249	Probability	0.000000
Obs*R-squared	92.07405	Probability	0.000000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 01/12/11 Time: 17:46
Sample (adjusted): 1/12/2006 1/04/2011
Included observations: 1251 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.808677	0.601979	4.665742	0.0000
RESID^2(-1)	0.088483	0.027914	3.169867	0.0016
RESID^2(-2)	0.031312	0.027928	1.121157	0.2624
RESID^2(-3)	0.092864	0.027818	3.338267	0.0009
RESID^2(-4)	0.082709	0.027928	2.961512	0.0031
RESID^2(-5)	0.172990	0.027914	6.197282	0.0000

R-squared	0.073600	Mean dependent var	5.283407
Adjusted R-squared	0.069880	S.D. dependent var	19.81501
S.E. of regression	19.11013	Akaike info criterion	8.743099
Sum squared resid	454670.5	Schwarz criterion	8.767712
Log likelihood	-5462.808	F-statistic	19.78249
Durbin-Watson stat	1.986909	Prob(F-statistic)	0.000000

TABLE 59: Results of „ordinary“ estimation (without GARCH-specification) and ARCH-test

While Engle's LM-statistic is calculated by multiplying the estimated R^2 with the number of observations, the F-test checks the joint significance of the squared lagged residuals. Both statistics reject the null of non-existence of ARCH-effects clearly, as indicated by the p-values (both 0.0000) reported in TABLE 59. Thus, the obtained results of the ARCH-test are entirely in line with the prior findings and strongly notify the existence of ARCH-effects.

Now if the LLB stocks' sample distribution is as well compared with the adjusted normal distributions and quantiles, as done with the VPB-stocks, one can again deduce that the occurrence of extreme values is more likely compared to the normal quantile and that the kurtosis of the series is higher compared to the normal distribution:

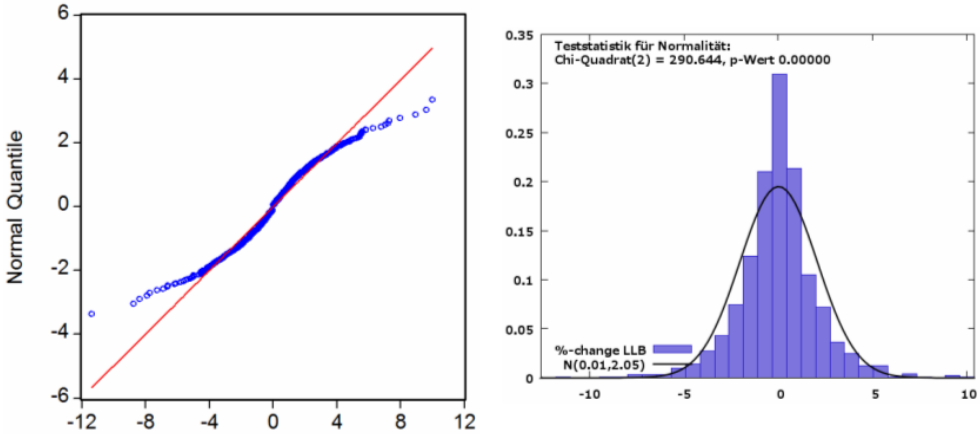

FIGURE 58: Comparison sample distribution/quantile with normal distribution/quantile (%ΔLLB)

The estimation without GARCH-modelling yields autocorrelated squared residuals. The reported results are shown below:

Dependent Variable: PD_LLB
Method: Least Squares
Date: 01/27/11 Time: 05:19
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PD_LLB(-1)	-0.055013	0.027140	-2.027017	0.0429
PD_SMI	0.416425	0.041392	10.06045	0.0000
FINANCIALCRISIS	0.080021	0.152443	0.524923	0.5997
DATATHEFT	-0.041855	0.090990	-0.459994	0.6456

R-squared	0.078506	Mean dependent var	0.014775
Adjusted R-squared	0.076298	S.D. dependent var	2.047996
S.E. of regression	1.968317	Akaike info criterion	4.195415
Sum squared resid	4850.590	Schwarz criterion	4.211770
Log likelihood	-2630.720	Durbin-Watson stat	2.063262

Correlogram of squared residuals ($\hat{u}_t^2$)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.225	0.225	63.565	0.000
		2	0.110	0.063	78.890	0.000
		3	0.101	0.067	91.670	0.000
		4	0.120	0.084	109.92	0.000
		5	0.149	0.103	138.09	0.000
		6	0.128	0.064	158.69	0.000
		7	0.185	0.131	201.95	0.000
		8	0.015	-0.083	202.23	0.000
		9	0.099	0.072	214.74	0.000
		10	0.073	0.002	221.42	0.000

TABLE 60: Results of "ordinary" estimation (without GARCH-specification) and correlogram of squared residuals

Also the autocorrelation function of $\%\Delta LLB^2$ shows a significant degree of autocorrelation and therefore a strong heteroskedastic pattern. Hence, the variance is not constant over time (heteroskedasticity and volatility clustering). Again, an ARCH-test as proposed by ENGLE [1982] is carried out. The reported results of the ARCH-test, as shown in TABLE 61, strongly indicate the existence of ARCH-effects since the null of insignificance of the lagged squared residuals[106] can be clearly rejected executing both the LM- and the F-test[107]:

106 Again, footnote 105 applies.
107 The test procedure has already been explained in further detail before.

Dependent Variable: PD_LLB
Method: Least Squares
Date: 01/27/11 Time: 05:19
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PD_LLB(-1)	-0.055013	0.027140	-2.027017	0.0429
PD_SMI	0.416425	0.041392	10.06045	0.0000
FINANCIALCRISIS	0.080021	0.152443	0.524923	0.5997
DATATHEFT	-0.041855	0.090990	-0.459994	0.6456

R-squared	0.078506	Mean dependent var	0.014775
Adjusted R-squared	0.076298	S.D. dependent var	2.047996
S.E. of regression	1.968317	Akaike info criterion	4.195415
Sum squared resid	4850.590	Schwarz criterion	4.211770
Log likelihood	-2630.720	Durbin-Watson stat	2.063262

ARCH Test:

F-statistic	17.49565	Probability	0.000000
Obs*R-squared	126.6722	Probability	0.000000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 01/13/11 Time: 19:16
Sample (adjusted): 1/17/2006 1/04/2011
Included observations: 1248 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.893423	0.316564	5.981176	0.0000
RESID^2(-1)	0.188414	0.028310	6.655276	0.0000
RESID^2(-2)	0.026926	0.028512	0.944367	0.3452
RESID^2(-3)	0.041435	0.028497	1.454037	0.1462
RESID^2(-4)	0.060222	0.028409	2.119808	0.0342
RESID^2(-5)	0.089206	0.028406	3.140347	0.0017
RESID^2(-6)	0.042265	0.028471	1.484501	0.1379
RESID^2(-7)	0.145438	0.028483	5.106122	0.0000
RESID^2(-8)	-0.083109	0.028285	-2.938254	0.0034

R-squared	0.101500	Mean dependent var	3.872228
Adjusted R-squared	0.095699	S.D. dependent var	8.891254
S.E. of regression	8.455117	Akaike info criterion	7.114606
Sum squared resid	88574.87	Schwarz criterion	7.151596
Log likelihood	-4430.514	F-statistic	17.49565
Durbin-Watson stat	1.987927	Prob(F-statistic)	0.000000

TABLE 61: Results of „ordinary“ estimation (without GARCH-specification) and ARCH-test

Hence, it truly makes sense to apply some GARCH-model to properly account for the existence of autoregressive heteroskedasticity, which is (from an econometric point of view) not especially surprising in the context of financial time series. But as already explained the analytic advantages of modelling the conditional variance also justify the use of a GARCH-model, since there is direct interested in influences not only on the average performance but especially on the risk (measured by the conditional variance).

3.A.5. Liechtenstein's Financial Sector and Zumwinkel-Affair

The "Liechtenstein Global Trust" (LGT) was founded in 1920. It is owned by the princely family of Liechtenstein. LGT has 1'985 employees (2010) worldwide. The "Liechtensteinische Landesbank AG" (LLB) is the oldest bank in Liechtenstein (founded in 1861) and employs 1'068 people (2010). The state of Liechtenstein holds the majority of LLB's shares. The "Verwaltungs- und Privatbank AG" (VPB) was founded in 1956, is privately owned and has 766 employees (2010).

Not only the financial sector but also the industrial export sector[108] was strongly affected by the world recession, which combined with bad performance within the financial sector led to a dramatically high real annual decrease of Liechtenstein's GDP (2008: -2,7%, 2009: -11,0%), which was even worse than in the first oil crisis of the mid-70s. These findings rely on estimates of the Konjunkturforschungsstelle Liechtenstein (2010, see SCHLAG [2012]), official national accounts (1998-2009, see OFFICE OF STATISTICS [2011]) and estimated figures by the author of this thesis (1972-1997)[109]. Following the estimations of the Konjunkturforschungsstelle Liechtenstein (KOFL), the year 2010 was the economic turning point featuring positive real GDP-growth (+7,7%) again.

An additional and good current example for the still ongoing international pressure on Liechtenstein, especially by Germany, were the negotiations between Deutsche Bank AG and LGT Bank AG about the sale of the BHF-Bank that belongs to Deutsche Bank. The Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht) subsequently delayed and as a consequence blocked the negotiations between the two banks. Therefore, the sale did not take place: An event which can be seen as being a direct consequence of the Zumwinkel-Affair (see FINANCIAL TIMES DEUTSCHLAND [2011]) and reflects possible restraints towards banks from Liechtenstein. As a consequence, the LGT closed its branches in Germany, which led to depreciations of around 50 million Swiss Francs and diminished the profits in 2011 from 120 to 70 million Swiss Francs (see HANDELSBLATT [2012]). As additional burden, the public prosecution department

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108 Even though Liechtenstein's industry sector has a very high share of the national gross value added (2008: 36%) and of total employment (2008: 46%) - both are considerably higher than in its surrounding countries such as Switzerland, Germany or Austria (where industrial employment usually is around 25%) - it is internationally mostly recognized for its financial sector. The financial sector in turn also has a comparable high share of the national gross value added (2008: 33%) and of total employment (2008: 16%). The total nominal national value added measured by GDP was 5'495 million Swiss Francs (in 2008). The total employment in Liechtenstein was 33'265 (2008), so GDP/employee was around 160'000 Swiss Francs. For further detailed statistics see OFFICE OF STATISTICS [2010].

109 A preliminary version of this historic GDP-time series has been presented in BRUNHART, KELLERMANN AND SCHLAG [2012], the final series has been estimated in chapter 1.4. of this dissertation.

of Bochum (Germany) fined the LGT with a monetary penalty of 50 million Euros, which was accepted and paid in 2010 (see NEUE ZÜRCHER ZEITUNG [2010]).

3.A.6. Comparison with Swiss Banks

As an additional application of the chosen augmented amalGARCH(0,1,1) it has also been inspected whether the results regarding the Zumwinkel Affair, which have been observed for the two inspected banks from Liechtenstein, the Verwaltungs- und Privatbank AG (VPB) and the Liechtensteinische Landesbank AG (LLB), also hold for banks in Switzerland. There are three banks with a comparable size to the VPB and the LLB that are quoted at the Swiss Stock Exchange: The "Bank Sarasin AG", the "Vontobel Holding AG" and the "Julius Bär Gruppe AG". Unfortunately, Julius Bär was split into two separate corporations in March 2009, which led to a structural break in the stock prices, since both corporations now had their own stocks. Hence, only the stocks of Sarasin and Vontobel are used here. The stock prices of these two banks and the SMI-index are depicted in FIGURE 59.

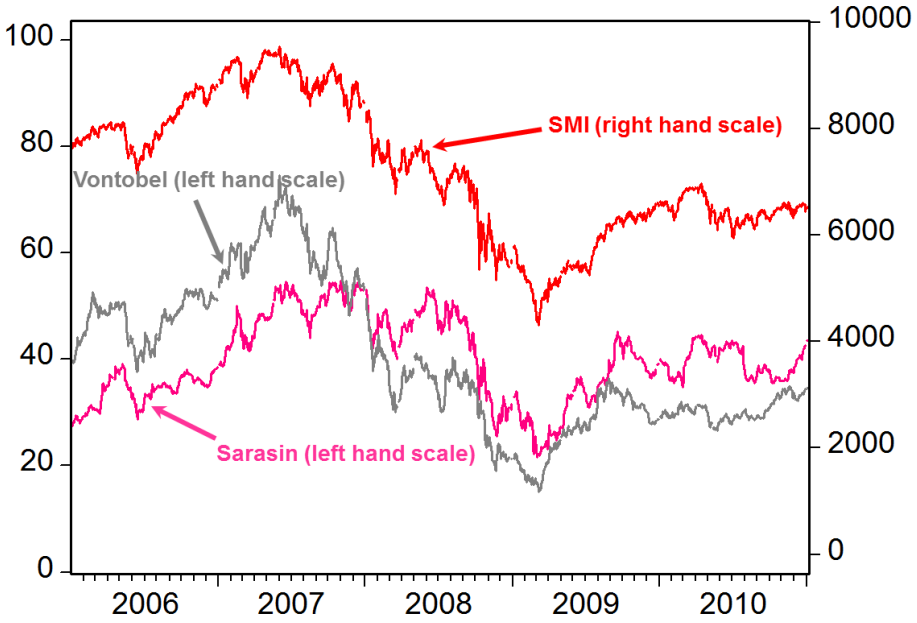

FIGURE 59: Stock prices of inspected banks and SMI-index

The output tables of the comparative estimations applying returns of stock price values of Swiss banks, which are mentioned towards the end of chapter 3.3., are visible in TABLE 62.

	Dependent Variable					
	$\%\Delta VONTOBEL$			$\%\Delta SARASIN_t$		
Assumed Distribution	Normal	Student's t	GED	Normal	Student's t	GED
(Conditional) Mean Equation						
$\%\Delta SARASIN_{t-1}$				0.1169***	0.0545**	0.0600***
$\%\Delta VONTOBEL_{t-1}$	0.0494*	0.04747*	0.0462*			
$\%\Delta SMI_t$	0.0097***	0.0093***	0.0092***	0.0068***	0.0061***	0.0062***
Financial Crisis	0.0004	0.0006	0.0007	0.0017	0.0004	-0.0003
Data Theft	0.0002	0.0001	0.0001	-0.0001	-0.0002	-0.0002
(Conditional) Variance Equation						
Constant	1.8E-5***	1.4E-5***	1.3E-5***	3.0E-5***	4.0E-05***	3.1E-05***
$GARCH(1)^{2)}: h_{t-1}$	0.8004***	0.8378***	0.8438***	0.7591***	0.6715***	0.7041***
$\%\Delta SARASIN^2_{t-1}$				0.0890***	0.1572***	0.1054***
$\%\Delta VONTOBEL^2_{t-1}$	0.0543***	0.0540***	0.0503***			
$\%\Delta SMI^2_{t-1}$	1.0E-5***	5.9E-6*	6.4E-6**	1.2E-5***	2.5E-5***	1.7E-5***
Financial Crisis	2.8E-5	2.6E-5*	2.3E-5*	2.2E-5*	0.0001**	5.7E-5*
Data Theft	-5.1E-7	2.0E-7	-3.2E-7	-1.1E-5***	-1.1E-5	-1.1E-5
Measures of Fit						
R^2	0.3004	0.3020	0.3020	0.2125	0.2080	0.2091
Adjusted R^2	0.2954	0.2963	0.2964	0.2068	0.2022	0.2027
Akaike Info Criterion	-5.3466	-5.3615	-5.3638	-5.2973	-5.4449	-5.4441
Schwarz Info Criterion	-5.3058	-5.3165	-5.3189	-5.2564	-5.4041	-5.3991

1) Past squared residual from the mean equation (past shocks).
2) Lagged conditional variance (serial time dependency of risk).
The magnitude of the relevant p-values are marked with stars and therefore reflects the significance of the respective parameter (*: p-value ≤ 0.10 and > 0.05, **: p-value ≤ 0.05 and > 0.01, ***: p-value ≤ 0.01). The p-value denotes the lowest significance level at which the null hypothesis (of insignificance in this case) could be rejected regarding the regressor's t-value (which is here the estimated coefficient of the regressor divided by the estimated standard error of the coefficient).
See sections 2.2. and 2.3. for the theoretical equation setup and estimation results of the main GARCH-models.

TABLE 62: Estimation output of the augmented amalGARCH-model for Swiss banks

There was no detectable impact of the sapid Zumwinkel-Affair on the Swiss banks' average stock returns, a similar finding compared to the banks in Liechtenstein. More interestingly, there was also no magnifying impact on the risk of the stocks by this prementioned affair that followed the data theft: For both banks, the coefficient of the data theft time dummy in the variance equation is extremely small and not

significant in almost all the settings.[110] This finding is a sharp contrast to the observations made for the two banks from Liechtenstein in this context. The chosen modelling setting, the augmented amalGARCH, and the conclusions drawn from it are therefore supported as the crucial findings are in line with economic and logical a-priori considerations and not just an artefact of the chosen econometric modelling specifications. The fact that the data theft and the revelation of tax evaders (and also the following international pressure on Liechtenstein, the investors' insecurity and the following transformation process within the financial services sector in Liechtenstein) seem to have magnified the volatility of stock values of Liechtenstein's banks but not of the Swiss banks is intuitive.

[110] The significance of the coefficient of the data theft dummy in the variance equation only appears for Sarasin and only if a normal distribution is assumed. The assumption of a normal distribution is, according to information criteria, inferior to the student's t distribution after BOLLERSLEV [1987] and the generalized error distribution after NELSON [1991], though. But also for Sarasin under the assumption of a normal distribution applies: The magnitude of the coefficient is extremely small and features a negative sign.

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Abstracts

[1.] Backward Calculation, Revision and Provision of Historic Economic Data Series to Enhance Econometric Research and Forecasting in Liechtenstein

ENGLISH: Several economic data series of Liechtenstein are backwardly estimated in order to achieve consistent historic time series. The generated series consist for instance of the national income 1954-1992 (regressive inter- and retropolation with indicators) and 1993-1997 (approximative computation after national accounting scheme), the sectoral and total employment of some missing years in the 70s, 80s and 90s and the gross domestic product 1972-1997 (approximative computation/estimation after generation of income account of national accounts). These series can be linked with the officially released results from the national accounts, which were introduced for the year 1998 and published until 2009 so far. Also, a benchmark model has been presented, which serves as a supporting supplement to the annual GDP-forecast for Liechtenstein's economy that is carried out by the KOFL Liechtenstein Economic Institute.

GERMAN: Verschiedene ökonomische Datenreihen für Liechtenstein werden zeitlich zurück geschätzt, um konsistente wirtschaftshistorische Zeitreihen zu erhalten. Die generierten Reihen bestehen unter anderem aus dem Volkseinkommen 1954-1992 (regressive Inter- und Retropolation mit Indikatoren) und 1993-1997 (approximative Berechnung nach der VGR), der sektoralen und totalen Beschäftigung für die 70er-Jahre und einzelne Jahre in den 80er und 90ern und dem Bruttoninlandsprodukt 1972-1997 (Berechnung/Schätzung nach dem Einkommens-entstehungskonto der VGR). Diese Zeitreihen können mit den offiziell publizierten Zahlen verbunden werden, welche bis anhin für die Jahre 1998 bis 2009 vorliegen. Zudem wird ein Benchmark-Modell präsentiert, welches als unterstützende Ergänzung dienen soll zu der BIP-Jahresprognose für Liechtensteins Wirtschaft durch die Konjunkturforschungsstelle Liechtenstein (KOFL).

[2.] The New Composite Index "KOFL KonSens": An Indicator for Liechtenstein's Sub-Annual Business Cycle

ENGLISH: The basis of data that are relevant for business cycle analysis in Liechtenstein is scarce, especially in sub-annual frequency. In this paper, the base of economic data is being extended by the development of a composite (coincident) business cycle indicator, the "KOFL KonSens". In this vein, a valuable complement to the ordinary business cycle definition, which concentrates on the cyclical deviation from the trend of certain separate economic aggregates, is being provided. By the detection and filtering of a common business cycle signal ("business cycle as a consensus") of multiple indicators, the KOFL KonSens as a "Konjunktur-Sensor" generates a broader foundation for business cycle analysis and therefore also a new base for prediction. All the work steps, relevant methods and first results are presented, whereby also quarterly figures for Liechtenstein's GDP are being estimated for the first time.

GERMAN: Die Basis konjunkturell relevanter Daten ist für Liechtenstein spärlich, speziell bei unterjähriger Frequenz. Im vorliegenden Paper wird durch die Erarbeitung eines konjunkturellen (gleichlaufenden) Sammelindikators, dem „KOFL KonSens", die Basis an wirtschaftlichen Daten erweitert sowie durch die Aggregation mehrerer Konjunkturindikatoren eine wertvolle Ergänzung bereitgestellt zum üblichen Konjunkturbegriff, der sich meistens nur auf die zyklische Trendabweichung einzelner Wirtschaftsdatenreihen stützt. Mit der Herausfilterung eines gemeinsamen konjunkturellen Signals („Business Cycle as a Consensus") mehrerer Indikatoren schafft der KOFL KonSens als "Konjunktur-Sensor" eine breiter abgestützte Grundlage für die unterjährige Konjunkturanalyse und verbessert darauf aufbauend auch die Prognosebasis. Im Text sind alle Arbeitsschritte, relevanten Methoden und erste Ergebnisse vorgestellt, dabei werden auch erstmals Quartalszahlen für das liechtensteinische BIP geschätzt.

[3.] Stock Market's Reactions to the Revelation of Tax Evasion: An Empirical Assessment

ENGLISH: Additionally to the financial crisis causing a world recession, Liechtenstein's financial sector has been challenged by the so-called "Zumwinkel-Affair" when a whistle-blower sold data of hundreds of tax evaders to international tax authorities. This paper investigates the impact of this affair, separated from the financial crisis, on the daily stock prices of banks from Liechtenstein. An "unconventional" augmented GARCH-model (labelled as "augmented amalGARCH"), which outperforms conventional models, is introduced and analyses the dynamical pattern and other influences on risk and average performance. Besides other findings, it can be concluded that the Zumwinkel-Affair had an (accumulating) effect on risk of stocks, but surprisingly no impact on average stock returns could be detected.

GERMAN: Zusätzlich zur Finanzkrise, die eine Weltrezession auslöste, wurde Liechtensteins Finanzsektor von der sogenannten „Zumwinkel-Affäre", ein Datendieb hatte internationalen Steuerbehörden Informationen von hunderten Steuerflüchtlingen verkauft, gefordert. Dieses Papier untersucht die Auswirkungen dieser Affäre, separiert von der Finanzkrise, auf die Aktienkurse der liechtensteiner Banken. Ein „unkonventionelles", erweitertes GARCH-Modell (bezeichnet als „augmented amalGARCH"), welches hier herkömmlichen Modellen überlegen ist, wird eingeführt und untersucht die dynamische Struktur und andere Einflüsse auf Risiko und Rendite. Neben anderen Erkenntnissen kann geschlussfolgert werden, dass die Zumwinkel-Affäre eine verstärkende Wirkung auf das Risiko hatte, überraschenderweise konnte aber kein Einfluss auf die durchschnittliche Rendite festgestellt werden.

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