Measuring Switzerland's Productivity Performance (1960-2008)

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Measuring Switzerland's Productivity Performance

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Abstract

The paper analyzes Switzerland's improvement in standard of living over the year 1960-2008. The paper utilizes index number and Translog production framework approach developed by Diewert, Lawrence, Wales, Morrison, Kohli and others. First a standard TFP measure is computed using index number approach followed by Kohli type real income decomposition. This is done for both gross output and the more theoretically preferable net output framework. The author find that under the gross framework Switzerland has an average TFP growth of 0.99%, while in the 80s and 90s it was less than 0.5%. This finding is consistent with those obtained using Solow residual econometric method of TFP growth measurement. It seems increasing TOFT provides part of the answer for real income growth, but labour also played a crucial role. Since Switzerland was not affected seriously during WWII, it entered the 50s and 60s with high income; as a result its growth rate is not that high. The author finds there has been definite improvement in standard of living in terms of increase consumption and leisure over investigated period. Then based on framework developed by Diewert etal the author investigates the production and consumer side of the economy, estimating requisite elasticity of labour, export, output etc. In each of these cases, succinct description of the theoretical framework involved is also provided. Finally benchmarking exercise is undertaken for the economy and it is found that within 1984-2008 periods, 2007 is the only efficient observation. Efficiency performance from mid 80s to mid 90s is very poor but after 2003 there has been improvement in efficiency performance but the longevity of this trend is a suspect given the recent economic crisis. The author in the conclusion also provides some rationale for the low TFP performance of Switzerland.

1. Introduction

Switzerland has a stable, modern and one of the most capitalist economies in the world. It has the 2nd highest European rating in the Index of Economic Freedom[1] 2010, while also providing large coverage through public services. Switzerland has an overwhelmingly private sector economy and low tax rates by Western standards; overall taxation is one of the smallest of developed countries. Switzerland is an easy place to do business; Switzerland ranks 21st of 178 countries in the Ease of Doing Business Index.

GDP (official exchange rate):	$489.8 billion (2009 est.)	
GDP Real Growth	-1.5% (2009 est)	
Total Labour	4.13 million	
Investment (gross fixed):	20.4% of GDP (2009 est.)	
Inflation rate (consumer prices):	-0.5% (2009 est.)	2.4% (2008 est.)
	2008	**2007**
Central bank discount rate:	0.05%	2.05%
Commercial bank prime lending rate:	3.34%	3.15%
Sector Contribution	**GDP**	**Labour**
Agriculture:	1.30%	3.80%
Industry:	27.60%	23.90%
Services:	71.00%	72.30%
Major Service and Industries	machinery, chemicals, watches, textiles, precision instruments, tourism, banking, and insurance	
Exports:	$207 billion (2009 est.)	
Exports - commodities:	machinery, chemicals, metals, watches, agricultural products	
Exports - partners:	Germany 19.7%, US 9.6%, Italy 8.7%, France 8.6%, UK 5.2% (2008)	
Imports:	$192.1 billion (2009 est.)	
Imports - commodities:	machinery, chemicals, vehicles, metals; agricultural products, textiles, oil	
Imports - partners:	Germany 33.3%, Italy 11%, France 9.4%, US 5.8%, Netherlands 4.5% (2008)	

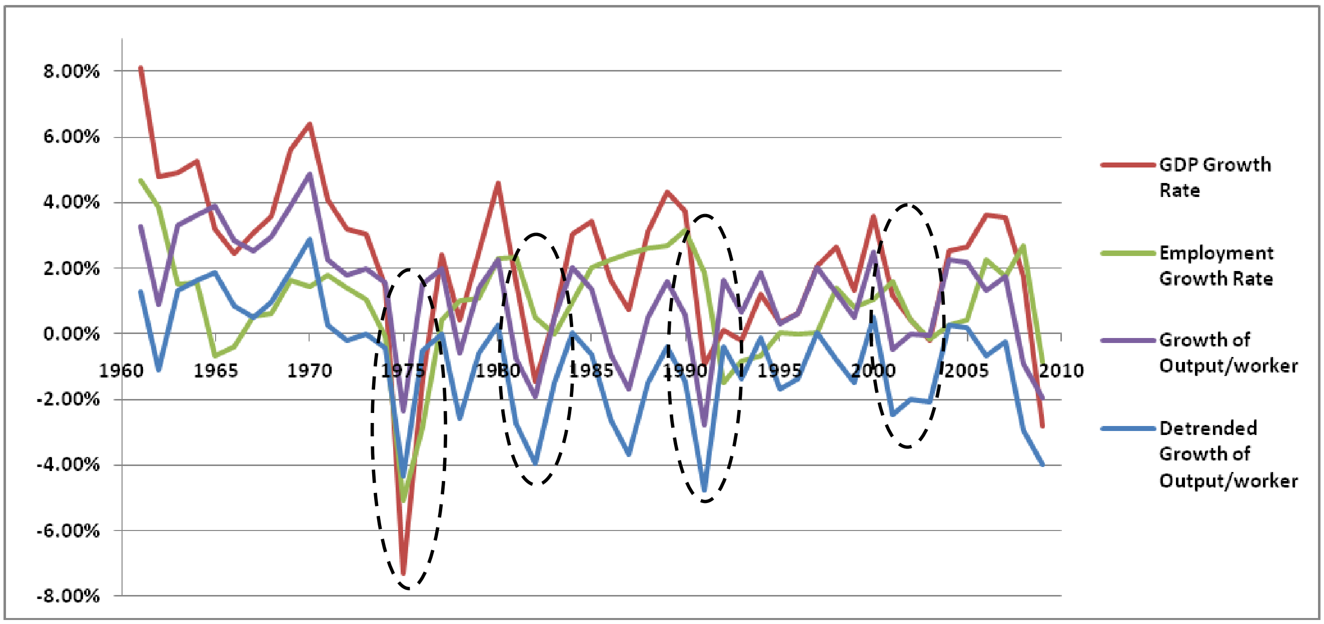
However Switzerland is found to have growth rate significantly lower than that of other developed nations. According to Dewald (2002), whose data series covers 1880-1995, Switzerland occupies second last position in the group of 12 countries in terms of per capita real growth. Gagales (2002) points out that Swiss growth performance in the past quarter century has been mediocre, with 1.5% GDP growth rate which was 0.75% lower than EU average and 1.5% lower than average growth rate among industrial countries. Gagale's paper finds that conditional income convergence contributes significantly to this slow growth, as predicted by neo-classical growth models. But he also finds that by international comparison, Switzerland has a very low average TFP growth.

Kehoe and Ruhl (2007) go so far as to suggest that Switzerland is suffering from great depression which started after the first oil shock in 1973. This is borne out by the fact that in the 1970s, GDP growth rates

[1] http://www.heritage.org/index/country/Switzerland

gradually declined from a peak of 6.5% in 1970 until contracting 7.5% in 1975 and 1976. Switzerland became increasingly dependent on oil imported from its main supplier, the OPEC cartel. The 1973 international oil crisis caused Switzerland's energy consumption to decrease from 1973 to 1977. From 1977 onwards GDP grew, however Switzerland was also affected by the 1979 energy crisis which resulted in a short term decrease of Switzerland's energy consumption. In the 1980s, Switzerland was affected by the hike in oil prices which resulted in a decrease of energy consumption until 1982 when the economy contracted by 1.3%. From 1983 on both GDP and energy consumption grew. In the following we see the graph of growth rate of Real GDP and Employment[2].

Figure 1: **GDP, Employment and Output/Labour Growth Rate**



In the above graph, the growth rate of output/worker ratio is also provided. There is also the detrended growth ratio which deducts 2% from the growth rate of output/worker ratio. This is based on by Kehoe and Prescott (2002) and Kehoe and Ruhl (2007), who argue that under the neoclassical framework relative to a global trend, country's performance is measures. This trend growth in TFP represents the world stock of useable production knowledge growing smoothly over time and that this knowledge is

[2] The data are taken from the "Total Economy Database (TED)" of Conference Board, NY. The author use the EKS GDP, which is the total GDP, in millions of 2009 US$ (converted to 2009 price level with updated 2005 EKS PPPs) and the Persons employed (in thousands of persons) for estimating the growth rate. GDP EKS series, where "EKS" stands for the originators of this PPP formula, Eltoto, Kovacs and Szulc, which essentially is a multilateral Fisher index, are measured in constant 2009 US dollars. It is updated from 2005 EKS PPPs with GDP deflator changes. These 2005 EKS PPPs are unpublished estimates from Penn World Tables (to be used in their upcoming version PWT 7), which are benchmarked on 2005 PPPs from the International Comparisons Project (ICP) at the World Bank (World Bank, 2005). As for the employment data, TED uses the employment figures reported under the National Accounts of Switzerland.

not country-specific. They define the trend growth rate to be 2 percent per year, corresponding to the growth rate of GDP per working-age person for the United States over the period 1920-2000. As a result the detrended graph uses data that are presented with the 2 percent trend removed. Kehoe and Prescott (2002) consider two characteristics important in defining a great depression. First, the deviation of output per working-age person from trend must be large, and second, the deviation from trend must occur quickly. With that notion they find that Switzerland has been in depression within the 1973-2000 periods.

We see this dismal performance of Switzerland from the above graph. It becomes evident that there were four periods (marked in dotted circle), where all four indicators dropped significantly. Although there was a fall in three of the indicator values in 1985, they still remained higher than the four slumps identified. Also per capita GDP and Employment growth rate remained relatively high during 1985 and that why it is not circled. In the 1990s, Switzerland's economy was marred by slow growth, having the weakest economic growth in Western Europe. The economy was affected by a 3-year-recession from 1991 to 1993 when the economy contracted by 2%. However, Gagales (2002) puts the duration of the recession from 1991 to 1996, thus including the time period when fiscal and monetary tightening took place. Switzerland's economy didn’t show any growth during the 1991-1996 periods. However, beginning in 1997, a global resurgence in currency movement provided the necessary stimulus to the Swiss economy and during 1997-2001 average GDP growth rate was 2%, peaking in the year 2000 with 3.6% growth in real terms.

In the early 2000’s recession, being so closely linked to the economies of Western Europe and the United States, Switzerland was not able to escape the slowdown felt in these countries. After the worldwide stock market crashes in the wake of the 9/11 terrorist attacks there were more announcements of false enterprise statistics and exaggerated managers' wages. In 2001 the rate of growth dropped to 1.2%, to 0.4 % in 2002 and in 2003 the real GDP contracted by 0.2%. Since then the economy began improving but in the wake of the stock market collapse, it has deeply affected investment income earned abroad. This has translated to a substantial fall in the surplus of the current account balance. The real GDP contracted by 2.8% in 2009, which can be seen in Figure 1 where post 2008 there is a significant drop in all indicator values. But unfortunately the present paper extends up to 2008 and therefore is unable to capture the full extent of the impact of global economic recession on Swiss Economy.

Kohli (2003) suggests that all is not lost for Switzerland; as a matter of fact he suggests that things have improved substantially. He shows that terms of trade have increased by 34% over 1980-1996 periods, the beneficial effect of which is not captured by real GDP. Also, since Real GDP is measured using laspeyre quantity Index, improvement in terms of trade actually leads to fall in real GDP. Another argument has been that since Switzerland was mostly unaffected by WWII unlike other Europeans countries, it had high per capita income to begin with and so under neoclassical Solow growth model, it is only to be expected that the growth rate is likely to be low. Another rationale is provided by Diewert etal (2005) and Diewert (2000), in that statistical agency lack data on financial assets, which might be significant for a country like Switzerland. There is no general consensus in constructing consistent and satisfactory measures of prices and quantities for these risky financial instruments and hence National Accounts do not report data on financial assets.

The present paper looks at the economic performance of Switzerland over the 1960-2008 year time period in a holistic manner. Initially conventional Total Factor Productivity growth approach is taken where TFP growth is measured as year to year Fisher gross output growth divided by Fisher primary input growth. In the paper the value of government output is measured by the value of government input (except input cost is understated because the opportunity cost tied up in govt capital is omitted). This essentially mean that productivity improvements in the govt sector are necessarily 0. Hence countries that have larger govt sectors will necessarily tend to have a lower productivity growth rate, all other factors equal. However it is well known that Switzerland has a decentralized federal system of governance and therefore it is likely that the underestimation will not be significant. In section 3, relevant fisher quantity and price indexes are developed for the computation of the TFP growth rate. The author also adjusted prices for tax whenever possible so that the adjusted prices reflect the prices that producers face, this is consistent with Jorgenson and Griliches and Diewert etal (2005). The paper provides estimates in both gross output concept and in theoretically preferred net output concept, the result vary significantly once this shift is made. In section 5 the author investigates the relative impact of productivity and terms of trade changes on Switzerland's welfare over the time period. In section 4, the paper elucidates the theoretic framework developed by Diewert (1983), Diewert and Morrison (1986), Morrison and Diewert (1990), Diewert and Lawrence (2005) and Kohli (1990) (1991) (2003) (2004a) (2004b). They developed a production theory methodology that enables one to obtain index number estimates of the contribution of each type of gain. However the section will not elaborate on significant detail as to the intricacies of the framework and will only provide the major pillars, thus for greater details once should look at the aforesaid papers.

In section 7 of the paper, the author employs the producer model initially developed by Diewert and Wales (1992) and then further improved upon by Diewert[3]; a brief theoretical description of the framework is also provided in section 6. In section 9, consumer models for Swiss data are tested; these models were initially developed by Diewert and Wales (1993) and further extended by Diewert[4]. Like before section 8 provides a brief theoretical foundation on the models involved. In section 10 the author undertakes benchmarking exercise using a nonparametric approach to production theory developed by Diewert[5]. In the following section, the author discusses the various problems faced in developing the requisite Swiss dataset for the aforementioned exercise. The following section discusses these in precise details.

2. Data Source and Issues

The primary sources of data for this paper are OECD.STAT and IMF's online International Financial Statistics databases. However in most of the cases data in the online repository do not go further back than 1970 and therefore in order to get older data for 1960s, following hardcopies were used:

I. National Accounts Main Aggregates 1960-1989 Volume 1

II. National Accounts Main Aggregates 1960-1997, 1999 Edition

In absence of wage data in OECD, IMF and ILO websites, the author used wage index from the Statistique de l'évolution des salaires Indice suisse des salaires[6] by Office fédéral de la statistique (OFS), published in 2009. The national index of wages (ISS) is an indicator of the evolution of the gross wages of employees in Switzerland. The wage index dates back to 1939 and has suffered over the years but it has been revised in 2006. Even so OFS cautions the use of this dataset due to this repeated up-gradation and change in methodology. For instance from 1942 until 1994, the wage was calculated on the basis of survey data of October survey on wages and salaries. Currently it is built on the basis of accident reports provided by the Department of centralized statistics of accident insurance (SSAA) or SUVA. However in absence of any other wage index covering the entire time period, the author employed this wage index.

The data for working hour was only available from 1991 onwards and thus for the prior data the author used the Total Economy Database[7]. The Total Economy Database is a comprehensive database with annual numbers of GDP, population, employment, hours and productivity for about 125 countries in the

[3] http://faculty.arts.ubc.ca/ediewert/594chmpg.htm/Chapter 9 Flexible Functional Forms

[4] ibid

[5] Tutorial presented at the University Autonoma of Barcelona, Spain, September 21-22, 2005; revised December, 2005.

[6] The national index of wages (ISS) is an indicator of the evolution of the gross wages of employees in Switzerland.

[7] http://www.ggdc.net/databases/ted.htm and http://www.conference-board.org/data/economydatabase/

world. The dataset was developed by the Groningen Growth and Development Centre, which was founded in 1992 within the Economics Department of the University of Groningen. Their estimates for other countries match up with OECD database and also their estimates for Switzerland matches for the available period. According to the notes provided by GGDC group, for the period 1950 and 1960 from they used Maddison (1995), "Monitoring the World Economy, 1820-1992", and linked it to 1970. For the 1961-1969, the data were interpolated, while for 1970-1990 it was extrapolated from 1991 with trend from OECD, Employment Outlook 2009.

The wholesale price indexes that was taken from the IMF publication international financial statistics yearbook, that was required to deflate inventory change into real inventory change, had missing data for 1960-62 periods. So it was estimated by taking ratio of PI to CPI for the period of 1963 and then using that ratio with CPI to estimate the missing value. Also data on Armed forces were missing and they were taken from Correlates of War website (mpiler variable). The Correlates of War project is an academic study of the history of warfare. It was started in 1963 at the University of Michigan by political scientist J. David Singer. The basic dataset is developed based on information taken from the U.S Arms Control and Disarmament Agency (ACDA) and the International Institute for Strategic Studies (IISS). It is interesting to note that IISS reports a significant drop in military personnel, moving from 28,000 troops in 2003 to 4,000 troops in 2005, 2006, and 2007. This drop is reversed in 2008 when Switzerland's troop level returns to 23,000. This change in troop levels seems to be tied to the Army XXI reforms that were adopted by the Swiss in 2003 that called for a drastic reduction in the force strength of the Swiss military, rather than any error on the part of IISS.

Finally there were no data on employees (WE), unpaid family workers (UP) , self employed prior(SE) prior to 1991. However the author used data from two journal articles, namely "The changing structure of male self-employment in Switzerland"[8] and "The Potential Labor Force and Labor Needs in Austria and Its Neighboring Countries"[9]. The papers together provided estimates for these working groups for the period 1960-2000, on 10 year interval period. However the age groups were different in the two papers; the first paper covered age group 20-64 while the second paper focused on 15-59 age groups. Since there were overlaps, the author was able to link the datasets in order to get estimates for 1960, 1970, 1980 and 1990 period. For the intervening period, linear interpolation was used.

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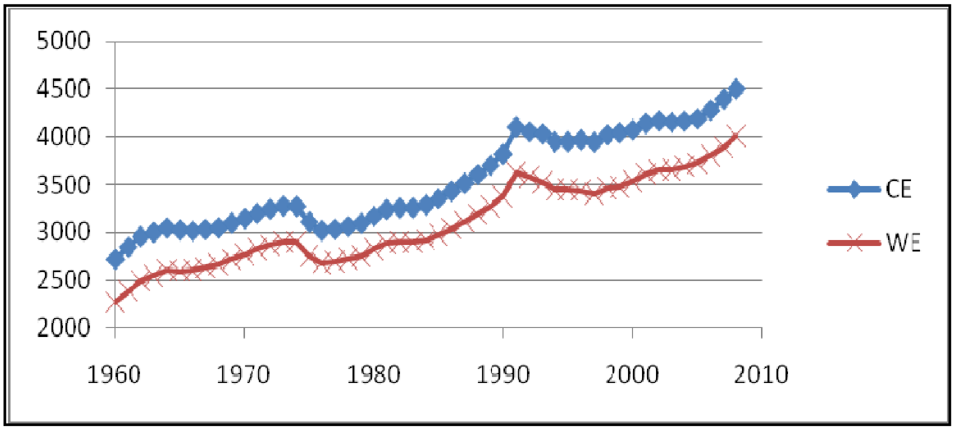
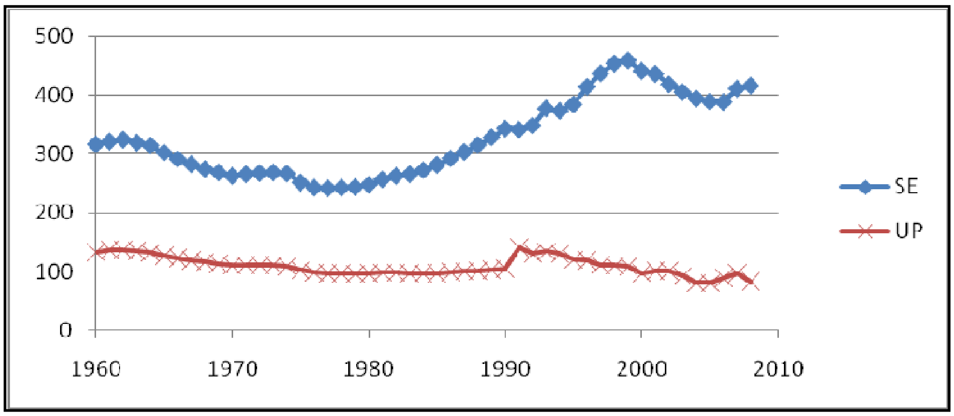
[8] Jean-Marc Falter *International Journal of Manpower* , Vol. 26 No. 3, 2005 pp. 296-312
[9] Friedrich Levcik and Michel Vale, *Eastern European Economics*, Vol. 15, No. 3 (Spring, 1977), pp. 47-102

Figure 2: Trend in Employment Data





As can be observed from the aforesaid figure that during the 1980-2000 periods the proportion of self employed in Switzerland showed a singular upward trend while it was diminishing prior to that period. Unpaid family workers remain relatively low in proportion and also stable. In the following section we will develop the relevant fisher quantity and price indexes needed for our TFP growth accounting exercise.

3. TFP Measurement and Indexing

In this section, we measure the productivity growth of the Swiss economy using a conventional chained Fisher index number approach. Basically, TFP growth is set equal to a chained Fisher output index divided by a chained Fisher primary input index. The output aggregate is an aggregate of the familiar C + I + G +X − M and the input aggregate is an aggregate of L + K, labour and capital services components. The production theory framework will be explained more fully in section 4 below when we shift our focus to real income measures.

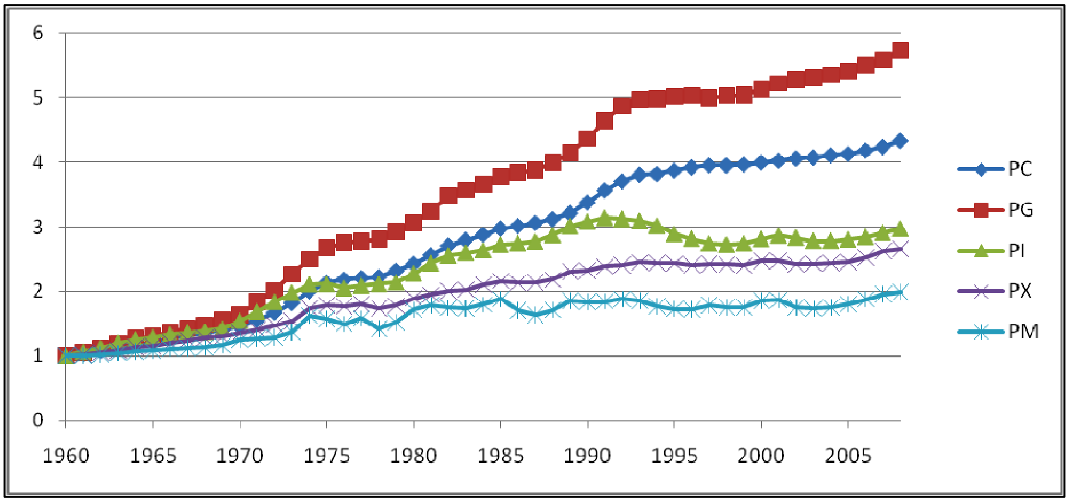
In the following table we see the fisher price index for the main aggregate data, where P stand for price and C is consumption, I is investment, G is government, X is export, M is import and TOFT is terms of trade. It is interesting to note that the price of government services grew the most by a factor of 5 , followed by consumption which has increased over 4 folds within the time periods. As Diewert explains that the rapid rise of PG is explained by the fact that govt output prices are measured by the prices of inputs used by the govt, primarily labour input prices, which always grow relative to the price of consumption (i.e., in all OECD countries, we have rising real wages over the sample period). Similarly he argues that the price of investment goods has the lowest rate of growth because of falling quality adjusted prices of machines, particularly those using computer chips.

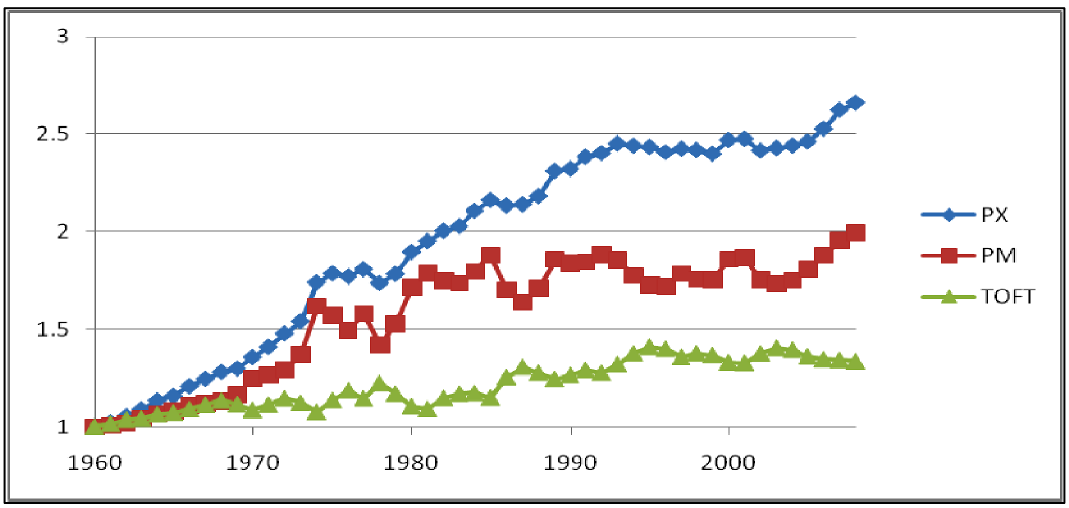
Table 1: Price Indices of Main Aggregates

YEAR	PC	PG	PI	PX	PM	TOFT
1960	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1961	1.0304	1.0480	1.0662	1.0202	1.0058	1.0143
1962	1.0811	1.1223	1.1277	1.0529	1.0154	1.0369
1963	1.1182	1.1834	1.2010	1.0882	1.0442	1.0421
1964	1.1655	1.2664	1.2555	1.1335	1.0673	1.0620
1965	1.2128	1.3057	1.2889	1.1562	1.0789	1.0717
1966	1.2703	1.3625	1.3321	1.2066	1.1077	1.0892
1967	1.3243	1.4280	1.3588	1.2443	1.1192	1.1118
1968	1.3581	1.4804	1.3787	1.2796	1.1289	1.1335
1969	1.3987	1.5502	1.4209	1.2972	1.1635	1.1150
1970	1.4527	1.6419	1.5444	1.3552	1.2481	1.0858
1971	1.5536	1.8345	1.6871	1.4076	1.2650	1.1128
1972	1.6719	2.0155	1.8410	1.4765	1.2903	1.1443
1973	1.8230	2.2646	1.9749	1.5394	1.3712	1.1227
1974	2.0052	2.5002	2.1107	1.7389	1.6168	1.0755
1975	2.1381	2.6763	2.1147	1.7851	1.5716	1.1359
1976	2.1860	2.7522	2.0521	1.7693	1.4936	1.1846
1977	2.2111	2.7713	2.0884	1.8068	1.5793	1.1441
1978	2.2246	2.8051	2.1143	1.7349	1.4192	1.2225
1979	2.3221	2.9196	2.1421	1.7819	1.5240	1.1692
1980	2.4270	3.0562	2.2780	1.8947	1.7159	1.1042
1981	2.5626	3.2438	2.4361	1.9492	1.7876	1.0904
1982	2.7106	3.4731	2.5533	2.0032	1.7472	1.1466
1983	2.7963	3.5686	2.5956	2.0265	1.7337	1.1689
1984	2.8799	3.6603	2.6338	2.1056	1.7960	1.1724
1985	2.9754	3.7792	2.7214	2.1602	1.8803	1.1489
1986	3.0152	3.8417	2.7450	2.1325	1.6999	1.2545
1987	3.0600	3.8750	2.7701	2.1385	1.6387	1.3050
1988	3.1197	3.9908	2.8732	2.1812	1.7096	1.2759
1989	3.2118	4.1420	3.0083	2.3097	1.8565	1.2442
1990	3.3784	4.3666	3.0776	2.3207	1.8361	1.2639
1991	3.5663	4.6399	3.1392	2.3822	1.8458	1.2906
1992	3.7077	4.8709	3.1229	2.4012	1.8817	1.2760
1993	3.8094	4.9601	3.0847	2.4499	1.8552	1.3205
1994	3.8203	4.9766	3.0155	2.4389	1.7725	1.3760
1995	3.8740	5.0195	2.8900	2.4328	1.7265	1.4090
1996	3.9232	5.0398	2.8130	2.4059	1.7204	1.3984
1997	3.9553	4.9973	2.7420	2.4239	1.7851	1.3578
1998	3.9528	5.0350	2.7221	2.4174	1.7560	1.3766
1999	3.9671	5.0417	2.7436	2.3976	1.7546	1.3665
2000	3.9994	5.1291	2.8082	2.4680	1.8559	1.3298
2001	4.0256	5.2169	2.8660	2.4745	1.8652	1.3267
2002	4.0601	5.2748	2.8300	2.4143	1.7549	1.3758
2003	4.0749	5.3140	2.7790	2.4274	1.7302	1.4029
2004	4.1094	5.3513	2.7813	2.4394	1.7502	1.3938
2005	4.1290	5.4068	2.8016	2.4601	1.8081	1.3606
2006	4.1839	5.4913	2.8441	2.5262	1.8782	1.3450
2007	4.2395	5.5871	2.9078	2.6229	1.9540	1.3423
2008	4.3338	5.7373	2.9706	2.6602	1.9927	1.3350

The following figures show the trend of these price indexes. It is worth noting that the finding of the present paper is congruent with Kohli (2003). There is significant rise in TOFT between 1980-1996 periods. However post 1996 it has been somewhat stable. It is worth noting that other European countries like Denmark, Sweden, Belgium, UK have TOFT much lower than Switzerland. In case of Belgium and Sweden it averages below 1. Even South Korea, being one of the Asian Tigers, has a much lower TOFT than Switzerland. Thus there might be credence to Kohli's claim that the Switzerland's improvement in TOFT is significant enough to compensate for its dismal or mediocre performance in other areas of productivity measurement. It is also interesting to note that during both the oil shocks (1973-74 and 1980-81), TOFT fell significantly as to be expected as Switzerland was highly dependent on oil import. Next we will look in to the fisher quantity indexes.

Figure 3: Trends in Price Indexes





In the following table, Q stands for quantity and like before C is consumption, I is investment, G is government, X is export, and M is import. These indexes are developed by calculating the quantity fisher index. Consumer products have grown by 2.84 folds, government services has gone up by 3.56 folds, while investment has increased by modest factor of 2.96 fold. We see greatest rise in export and import both of which show significant increase over the time period. Both export and import have increased almost 10 folds over the year. It is interesting to note that both export and import have started to increase rapidly after 2003. Other European countries like Denmark, Sweden, UK show similar pattern with Export and Import showing the fastest growth followed by consumption.

Table 2: Quantities of Main Aggregates					
YEAR	QC	QG	QI	QX	QM
1960	25.045	2.863	12.936	11.571	11.154
1961	26.719	3.363	15.214	12.488	13.349
1962	28.448	3.634	15.959	13.259	14.713
1963	29.786	3.956	16.563	13.982	15.425
1964	31.237	4.057	18.099	14.850	16.791
1965	32.297	4.243	17.416	15.959	16.798
1966	33.245	4.328	17.410	16.779	17.383
1967	34.249	4.396	18.135	17.357	18.095
1968	35.532	4.565	18.46	19.093	19.578
1969	37.484	4.794	19.524	21.648	22.129
1970	39.492	5.023	22.639	23.143	25.214
1971	41.372	5.316	23.958	24.043	26.784
1972	43.622	5.469	24.529	25.573	28.732
1973	44.826	5.601	25.135	27.583	30.600
1974	44.608	5.696	25.133	27.867	30.302
1975	43.304	5.733	18.994	26.037	25.65
1976	43.766	5.892	17.691	28.459	28.999
1977	45.092	5.916	17.883	31.225	31.681
1978	46.093	6.035	19.18	32.385	35.143
1979	46.681	6.098	21.409	33.184	37.551
1980	47.907	6.156	24.426	34.866	40.254
1981	48.414	6.311	23.546	37.225	39.729
1982	48.579	6.38	21.68	36.591	39.522
1983	49.147	6.621	21.009	37.275	41.718
1984	49.784	6.736	23.772	40.429	45.583
1985	50.599	6.959	24.473	43.652	47.307
1986	51.776	7.186	24.977	44.207	51.335
1987	52.91	7.299	25.97	44.814	54.486
1988	53.819	7.631	28.293	47.591	57.217
1989	55.08	8.036	30.792	50.475	60.516
1990	55.754	8.474	32.856	51.882	62.479
1991	56.698	8.743	30.052	51.336	61.637
1992	56.888	8.8	27.164	53.054	59.613
1993	56.582	8.694	26.517	53.813	59.562
1994	57.196	8.791	29.203	54.836	64.158
1995	57.564	8.808	30.545	55.151	66.700
1996	58.18	8.948	30.265	57.188	69.380
1997	59.014	8.98	30.616	63.617	74.974
1998	60.302	8.881	32.792	66.359	80.496
1999	61.692	8.922	33.169	70.659	83.833
2000	63.178	9.126	34.704	79.486	92.472
2001	64.605	9.533	32.923	79.881	94.578
2002	64.66	9.65	32.462	79.791	93.555
2003	65.251	9.833	32.429	79.429	94.808
2004	66.271	9.909	33.925	85.726	101.717
2005	67.377	10.024	34.894	92.387	108.445
2006	68.447	10.057	36.716	101.936	115.531
2007	70.071	10.105	38.83	111.671	122.407
2008	71.229	10.097	38.258	114.861	122.941

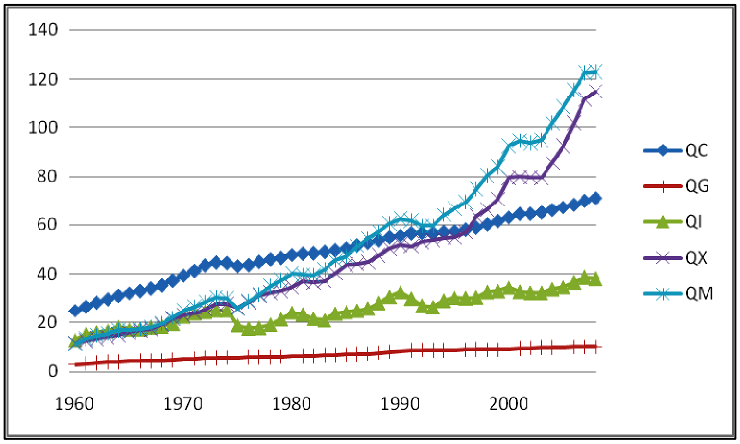


Figure 4 :Trends in Quantity Indexes

Next we will look in to some of the input series, which are much more difficult to develop as under the current national account system, they do not break up input values into price and quantity components. We take the value of depreciation to be Consumption of fixed capital in national currency. But as McDaniel (2007) points out there is a caveat in using this as depreciation. It is not intended to be used as a measure of deductible depreciation. According to 1993 SNA section 6.179 of United Nations Statistics Division 1993:

"Consumption of fixed capital is defined in the System in a way that is intended to be theoretically appropriate and relevant for purposes of economic analysis. Its value may deviate considerably from depreciation as recorded in business accounts or as allowed for taxation purposes..."

The above writing is taken from McDaniel (2007). He calculated average tax rates on capital income for the UK in 1970-2003 using income gross of depreciation and net. The average tax rate on income calculated net of depreciation and it reached levels above 80% in the 1980s. Thus getting high depreciation on capital income may be because of our choice of data.

Table 3: Capital Data							
YEAR	K	PD,PI	QI	QD	DRATE	QKS	PKS
1960	187.511	1.000	12.936	6.563	3.50%	17.019	1.000
1961	193.885	1.066	15.214	6.976	3.60%	17.598	1.094
1962	202.122	1.128	15.959	7.159	3.54%	18.345	1.165
1963	210.922	1.201	16.563	7.327	3.47%	19.144	1.216
1964	220.158	1.255	18.099	7.982	3.63%	19.982	1.299
1965	230.274	1.289	17.416	8.442	3.67%	20.900	1.313
1966	239.248	1.332	17.410	8.967	3.75%	21.715	1.371
1967	247.691	1.359	18.135	9.490	3.83%	22.481	1.404
1968	256.336	1.379	18.460	10.209	3.98%	23.266	1.448
1969	264.587	1.421	19.524	10.794	4.08%	24.015	1.541
1970	273.317	1.544	22.639	11.514	4.21%	24.807	1.665
1971	284.442	1.687	23.958	11.988	4.22%	25.817	1.725
1972	296.412	1.841	24.529	12.637	4.26%	26.903	1.868
1973	308.304	1.975	25.135	12.749	4.14%	27.983	1.943
1974	320.690	2.111	25.133	12.691	3.96%	29.107	1.946
1975	333.131	2.115	18.994	11.902	3.57%	30.236	1.735
1976	340.223	2.052	17.691	11.988	3.52%	30.880	1.704
1977	345.925	2.088	17.883	12.641	3.65%	31.397	1.734
1978	351.167	2.114	19.180	12.830	3.65%	31.873	1.741
1979	357.517	2.142	21.409	12.871	3.60%	32.449	1.773
1980	366.054	2.278	24.426	13.017	3.56%	33.224	1.877
1981	377.462	2.436	23.546	13.204	3.50%	34.260	1.981
1982	387.804	2.553	21.680	13.458	3.47%	35.198	1.934
1983	396.026	2.596	21.009	14.017	3.54%	35.944	1.860
1984	403.018	2.634	23.772	14.571	3.62%	36.579	2.072
1985	412.219	2.721	24.473	15.354	3.73%	37.414	2.163
1986	421.338	2.745	24.977	15.903	3.77%	38.242	2.105
1987	430.412	2.770	25.970	16.762	3.89%	39.065	2.065
1988	439.620	2.873	28.293	17.743	4.04%	39.901	2.150
1989	450.170	3.008	30.792	19.095	4.24%	40.859	2.272
1990	461.867	3.078	32.856	20.240	4.38%	41.920	2.362
1991	474.483	3.139	30.052	21.014	4.43%	43.065	2.246
1992	483.521	3.123	27.164	21.772	4.50%	43.886	2.221
1993	488.912	3.085	26.517	22.095	4.52%	44.375	2.260
1994	493.335	3.015	29.203	22.108	4.48%	44.776	2.386
1995	500.430	2.890	30.545	22.463	4.49%	45.420	2.236
1996	508.512	2.814	30.265	23.186	4.56%	46.154	2.193
1997	515.591	2.742	30.616	23.818	4.62%	46.797	2.190
1998	522.390	2.722	32.792	24.603	4.71%	47.414	2.210
1999	530.578	2.744	33.169	25.516	4.81%	48.157	2.263
2000	538.231	2.808	34.704	26.419	4.91%	48.851	2.364
2001	546.515	2.866	32.923	27.340	5.00%	49.603	2.074
2002	552.099	2.830	32.462	28.019	5.08%	50.110	2.084
2003	556.542	2.779	32.429	28.744	5.17%	50.513	2.136
2004	560.227	2.781	33.925	29.156	5.20%	50.848	2.386
2005	564.996	2.802	34.894	29.694	5.26%	51.281	2.340
2006	570.195	2.844	36.716	30.297	5.31%	51.753	2.535
2007	576.615	2.908	38.830	30.928	5.36%	52.335	2.787
2008	584.516	2.971	38.258	31.799	5.44%	53.052	2.768

Table 3 provides the estimated depriciation rate and relevent variables required for its calculation. K stands for the calculated capital stock, the methods of calculating the capital stock will be discussed shortly. PD/PI, Price of Depreciation is set equal to the Price of Investment. QI is quantity of Invertment calculated before. QD is amount of depriciation, which is calculated by dividing the Consumption of fixed capital measure by PD. DRATE stands for Depreciation Rate calculated under method 1, QKS is Quantity of Capital Services and PKS is Price of Capital Services (will be discussed later).

Before we proceed in to describing the methodology of depreciation rate calculation, there were some data related issues. The author linked the consumption of fixed capital (VD) data taken from hardcopies to the ones taken from OECD.STAT. This is because it was measured differently before and so the figure for 1970 in old system is CHE 10,770 million while in OECD.STAT the same figure for 1970 is CHE 17,782 million. In order to avoid structural break the author multiplied all the figures taken from hardcopy with the ratio of VD value in OECD.STAT to VD value for 1970 in hard copy.

In estimating depreciation rate first we need to calculate the capital stock and the paper uses two methods outlined in Diewert and Lawrence (2000).

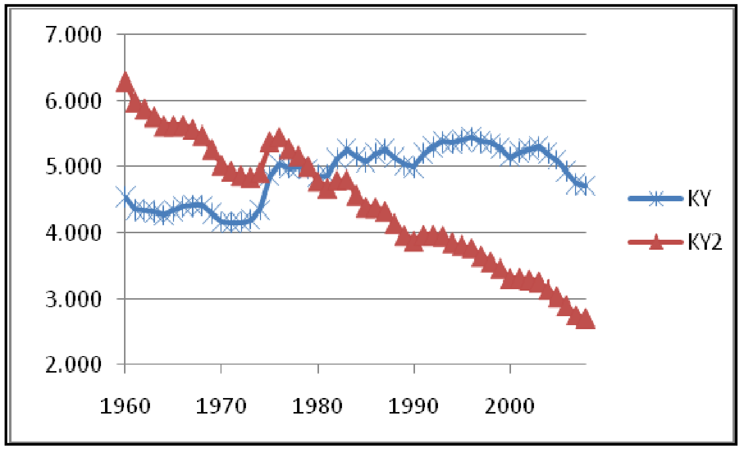
The first method uses the geometric model of depreciation and assumes an initial capital stock of zero. Since initially starting capital stock is assumed to be zero the resulting estimates for capital stock is not accurate for the first 30 or so years. But by the end of the sample period, a pretty accurate estimate for capital stock is developed, assuming that the official depreciation estimates are reasonably accurate. Hence through successive iterations more reliable estimates of the capital stock are built. The sample average depreciation rate is found to be 4.1922% , which may not be reasonable. As Diewert explains that the reproducible capital stock is made up of 3 components: inventories (depreciation rate is close to 0), structures (depreciation rate is between 2% and 6% and machinery and equipment (depreciation rate is between 6% and 20%) per year. Thus even if we neglect inventories for the moment and assume the capital stock is half structures and half machinery and equipment, then the average depreciation rate should be between 4% and 13% or perhaps around 8.5% per year. Adding inventories into the mix might reduce the average depreciation rate to the 6-7% range. Hence 4.1922% seems very low but may still be possible. Thus it might be prudent to estimate the result using the second method. It is also worth noting that if we did not use the linking procedure mentioned before, not only do we see structural break in 1970 but also convergence in DRATE takes place at an even lower level of 2.70%, which is even more improbable.

In the second method it i**s** assumed that the depreciation rate is constant over two consecutive periods, which allows us to solve for each year's depreciation rates and thus build our capital stock series. This is essentially the geometric capital accumulation model. However it is found that these implied depreciation rates are too volatile to be used directly so they are smoothed by running a regression against a linear time trend. Under this method the average depreciation rate over our sample period seems to be about 6.94% and the rate is strongly increasing over time, which is very reasonable. Using this predicted depreciation rate, new capital stock (K2) is developed. In the following table 4, depreciation rate (DRATE, DRATE2), capital stock (K, K2) under both methods are provide. In order to choose between the two estimates we use one of the growth fact identified by Nicholas Kaldor. Kaldor noted that the US and most other industrial countries were characterized by Output and capital growing at approximately similar rates so that the K/Y ratio is constant on average. Thus the next table also provides the capital output ratio (KY, KY2) for the two methods, and output (QY) is also given.

	Table 4 Different Measure of Depreciation Rate						
YEAR	K	K2	QY	KY	KY2	DRATE	DRATE2
1960	187.510	259.860	41.260	4.544	6.298	3.50%	2.53%
1961	193.880	266.230	44.470	4.360	5.986	3.60%	2.71%
1962	202.120	274.230	46.660	4.332	5.877	3.54%	2.89%
1963	210.920	282.250	48.930	4.311	5.768	3.47%	3.08%
1964	220.160	290.130	51.600	4.266	5.622	3.63%	3.26%
1965	230.270	298.760	53.130	4.335	5.624	3.67%	3.45%
1966	239.250	305.880	54.360	4.401	5.627	3.75%	3.63%
1967	247.690	312.180	56.040	4.420	5.570	3.83%	3.82%
1968	256.340	318.400	58.130	4.409	5.477	3.98%	4.00%
1969	264.590	324.120	61.530	4.300	5.268	4.08%	4.19%
1970	273.320	330.080	65.610	4.166	5.031	4.21%	4.37%
1971	284.440	338.300	68.570	4.148	4.934	4.22%	4.55%
1972	296.410	346.860	71.230	4.161	4.869	4.26%	4.74%
1973	308.300	354.950	73.390	4.201	4.837	4.14%	4.92%
1974	320.690	362.620	73.740	4.349	4.918	3.96%	5.11%
1975	333.130	369.230	68.520	4.861	5.388	3.57%	5.29%
1976	340.220	368.690	67.590	5.033	5.455	3.52%	5.48%
1977	345.930	366.200	69.420	4.983	5.275	3.65%	5.66%
1978	351.170	363.360	70.340	4.993	5.166	3.65%	5.84%
1979	357.520	361.300	72.060	4.961	5.014	3.60%	6.03%
1980	366.050	360.930	75.520	4.847	4.779	3.56%	6.21%
1981	377.460	362.940	77.530	4.869	4.681	3.50%	6.40%
1982	387.800	363.270	75.740	5.120	4.796	3.47%	6.58%
1983	396.030	361.040	75.120	5.272	4.806	3.54%	6.77%
1984	403.020	357.620	78.220	5.152	4.572	3.62%	6.95%
1985	412.220	356.540	81.120	5.081	4.395	3.73%	7.13%
1986	421.340	355.580	81.040	5.199	4.388	3.77%	7.32%
1987	430.410	354.530	81.860	5.258	4.331	3.89%	7.50%
1988	439.620	353.910	85.510	5.141	4.139	4.04%	7.69%
1989	450.170	354.990	89.530	5.028	3.965	4.24%	7.87%
1990	461.870	357.840	92.370	5.000	3.874	4.38%	8.06%
1991	474.480	361.870	91.300	5.197	3.964	4.43%	8.24%
1992	483.520	362.110	91.250	5.299	3.968	4.50%	8.42%
1993	488.910	358.770	90.800	5.384	3.951	4.52%	8.61%
1994	493.330	354.400	92.100	5.357	3.848	4.48%	8.79%
1995	500.430	352.440	92.540	5.408	3.809	4.49%	8.98%
1996	508.510	351.350	93.180	5.457	3.770	4.56%	9.16%
1997	515.590	349.420	95.710	5.387	3.651	4.62%	9.35%
1998	522.390	347.380	97.560	5.355	3.561	4.71%	9.53%
1999	530.580	347.070	100.350	5.287	3.458	4.81%	9.72%
2000	538.230	346.520	104.600	5.145	3.313	4.91%	9.90%
2001	546.520	346.920	104.560	5.227	3.318	5.00%	10.08%
2002	552.100	344.860	104.840	5.266	3.289	5.08%	10.27%
2003	556.540	341.920	104.900	5.306	3.260	5.17%	10.45%
2004	560.230	338.610	107.780	5.198	3.142	5.20%	10.64%
2005	565.000	336.520	110.710	5.103	3.040	5.26%	10.82%
2006	570.200	335.000	115.610	4.932	2.898	5.31%	11.01%
2007	576.610	334.850	121.520	4.745	2.756	5.36%	11.19%
2008	584.520	336.210	123.970	4.715	2.712	5.44%	11.01%

In theory, DRATE and DRATE2 should be close to each other but obviously, this did not turn out to be the case for Switzerland. The starting capital stocks k and k2 are not too close to each other, but k does grow a lot faster than k2. As an aid to choosing between k and k2, we look at the capital output ratios, as mentioned before, that correspond to each series. We would expect some gradual increase in capital output ratios over time.

Figure 5: Capital Output Ratio for two methods



We expect the capital output ratio to be between 2 and 4 with a slight increasing trend over time as capital deepening occurs in most OECD economies. Thus K is looking good; KY hovers around 4.5-5.2% with a slight increasing trend. On the other hand, K2 is not meeting expectations: the corresponding capital output ratio KY2 shows a singular downward trend with occasional ups. According to Gagales (2002), Switzerland has very high capital output ratio and is increasing, which is precisely what we see in this table. Next we look in to other input series, labour.

Table 5 : Labour Data							
YEAR	HOURS	VE	QE	VL	QL	PE,PL	W
1960	2047	19.345	19.345	21.518	21.518	1.000	1.000
1961	2040	21.925	20.535	24.276	22.738	1.068	1.063
1962	2032	24.595	21.357	27.143	23.570	1.152	1.140
1963	2025	27.460	21.646	30.214	23.817	1.269	1.221
1964	2018	30.520	22.022	33.471	24.151	1.386	1.316
1965	2010	33.130	21.913	36.214	23.952	1.512	1.412
1966	2003	35.300	21.910	38.454	23.868	1.611	1.515
1967	1996	38.335	22.063	41.626	23.957	1.738	1.614
1968	1989	40.925	22.233	44.296	24.065	1.841	1.691
1969	1981	44.085	22.635	47.566	24.422	1.948	1.794
1970	1974	49.605	22.992	53.353	24.730	2.157	1.963
1971	1964	59.105	23.302	63.534	25.049	2.536	2.210
1972	1940	67.181	23.358	72.172	25.093	2.876	2.452
1973	1913	76.588	23.300	82.230	25.017	3.287	2.746
1974	1885	85.151	22.956	91.368	24.633	3.709	3.081
1975	1876	87.262	21.729	93.574	23.301	4.016	3.313
1976	1873	87.805	21.100	94.099	22.612	4.161	3.382
1977	1846	89.865	20.858	96.263	22.344	4.308	3.463
1978	1832	94.471	20.926	101.138	22.402	4.515	3.574
1979	1819	99.503	21.056	106.452	22.527	4.726	3.691
1980	1805	107.245	21.389	114.668	22.870	5.014	3.890
1981	1785	116.186	21.633	124.325	23.148	5.371	4.132
1982	1774	124.665	21.587	133.500	23.117	5.775	4.423
1983	1760	130.149	21.426	139.463	22.959	6.074	4.588
1984	1741	135.253	21.358	145.055	22.906	6.333	4.717
1985	1735	143.529	21.672	154.057	23.262	6.623	4.864
1986	1726	152.615	22.016	163.945	23.650	6.932	5.037
1987	1725	160.372	22.511	172.416	24.201	7.124	5.158
1988	1724	170.471	23.085	183.405	24.837	7.384	5.338
1989	1709	182.953	23.429	197.014	25.229	7.809	5.540
1990	1700	199.580	24.045	215.065	25.910	8.300	5.864
1991	1698	214.281	25.796	230.391	27.736	8.307	6.272
1992	1707	221.090	25.672	237.970	27.632	8.612	6.574
1993	1704	223.860	25.254	242.492	27.356	8.864	6.750
1994	1725	225.197	25.055	244.051	27.153	8.988	6.846
1995	1704	230.643	24.753	250.223	26.855	9.318	6.938
1996	1678	231.869	24.313	252.893	26.517	9.537	7.022
1997	1665	234.787	23.854	257.203	26.131	9.843	7.055
1998	1672	239.147	24.375	262.311	26.735	9.811	7.103
1999	1694	243.766	24.835	267.455	27.249	9.815	7.125
2000	1688	254.273	25.076	277.549	27.371	10.140	7.217
2001	1650	269.155	24.980	293.167	27.209	10.775	7.393
2002	1630	276.480	24.978	299.985	27.102	11.069	7.526
2003	1643	276.760	25.240	299.323	27.298	10.965	7.632
2004	1673	277.085	25.841	298.726	27.860	10.723	7.702
2005	1667	287.393	25.888	309.467	27.876	11.102	7.776
2006	1652	299.563	26.217	322.256	28.203	11.426	7.868
2007	1643	315.377	26.661	340.183	28.758	11.829	7.996
2008	1640	333.657	27.537	358.885	29.619	12.117	8.158

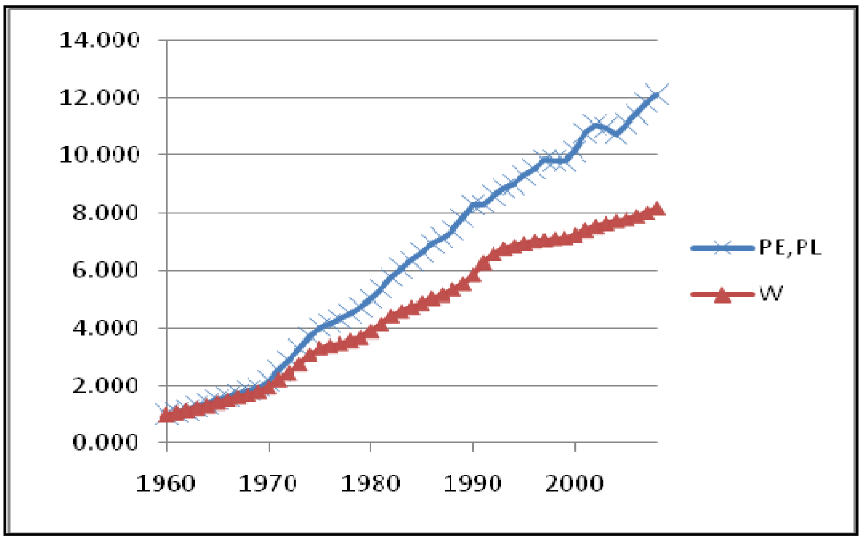
Hours represent the annual hours worked in Switzerland. VE is compensation of Employees and is taken from National Account at OECD.STAT. W is the wage indices taken from OFS, it has been renormalized so that in 1960 it has a value of 1. QE is the quantity series of employee labour. It is estimated by the product of total wage earner series and annual working hour, normalized to 1960. The exact formulation of the series is:

QE = TWE*HOURS*{VE(1960)/QE(1960)}

Before developing a wage rate for all types of workers, we need to account for the labour contribution to output growth of the self employed and the unpaid family workers. Diewert posits that surveys have shown that the self employed work fewer hours than employees on average and the unpaid family workers are generally much less productive than employees. In view of this we will assume that the self employed earn 2/3 of the wage of employees and the unpaid family workers earn only 1/3 of the employee wage. Based on this fisher price and quantity index are developed, QL being Quantity of Labour and PL, wage rate for all types of worker.

Note that PE (the wage rate for employees) is equal to the wage rate for all types of worker (PL). This is an application of hicks' aggregation theorem since we have made the wages of the self employed and unpaid family workers, proportional to the wage of employees. John Hicks examined the issue of aggregation from the perspective of the relationship between the prices of the products in a group. Specifically, rather than investigating aggregation when the products in X_i are always used in fixed proportion, Hicks demonstrated that, if the prices of the products in an aggregating group always stayed in fixed proportion to each other, then it is permissible to treat that product group as a single (i.e. aggregate) product. The following graph shows the different measure of wage rate and their evolution.

Figure 6: Trend in Wage rate Data



Thus from Table 5 we see that wages based on Swiss data grew 8.15 fold over the sample period while a broader measure of implicit wages grew 12.11 fold. The wage data taken from OFS, is estimated from data collected by SUVA files, the Swiss accident insurance fund for employees. According to Attilio Zanetti's[10] the actual wage has grown at least 1.5% faster than SUVA wages. Thus we will use PE as our measure of employee wages and QE as the corresponding quantity measure. It is worth noting that OFS itself has cautioned the use of their data W, as it might be of low quality, as mentioned previously. In the following section we estimate the tax rates on various parameters of the economy.

[10] "Do Wages Lead Inflation? Swiss evidence", Swiss National Bank (2005)

Table 6: Tax Rates					
YEAR	TRC	TRM	TRL	TRK	TRKI
1960	5.07%	13.05%	14.72%	0.65%	11.70%
1961	5.46%	11.66%	14.77%	0.66%	11.47%
1962	5.84%	10.27%	14.82%	0.66%	11.27%
1963	6.22%	8.88%	14.87%	0.66%	11.56%
1964	6.61%	7.49%	14.91%	0.66%	11.50%
1965	6.99%	6.10%	14.96%	0.67%	11.93%
1966	7.05%	5.73%	16.09%	0.71%	12.63%
1967	7.20%	5.74%	16.10%	0.70%	12.59%
1968	7.46%	5.48%	16.89%	0.78%	14.05%
1969	7.69%	5.14%	18.45%	0.81%	13.99%
1970	8.13%	3.67%	18.68%	0.83%	14.86%
1971	8.00%	3.50%	17.88%	0.81%	15.98%
1972	8.29%	3.59%	17.99%	0.84%	16.93%
1973	8.14%	3.11%	21.19%	0.86%	17.94%
1974	7.88%	2.33%	22.40%	0.86%	19.51%
1975	7.82%	2.51%	24.11%	0.86%	22.32%
1976	7.98%	2.05%	26.04%	0.93%	23.08%
1977	8.26%	1.76%	26.38%	0.88%	22.70%
1978	8.59%	1.79%	26.03%	0.86%	22.54%
1979	8.37%	1.58%	25.48%	0.85%	21.59%
1980	8.37%	1.38%	25.20%	0.82%	20.78%
1981	8.30%	1.36%	25.13%	0.81%	20.89%
1982	8.29%	1.40%	25.13%	0.83%	24.30%
1983	8.40%	1.32%	25.30%	0.85%	28.63%
1984	8.45%	1.13%	26.44%	0.88%	24.81%
1985	8.55%	1.07%	25.37%	0.91%	25.95%
1986	8.81%	1.27%	25.91%	1.00%	31.29%
1987	8.96%	1.22%	25.05%	1.00%	34.85%
1988	9.12%	1.17%	25.36%	1.02%	37.19%
1989	9.09%	1.03%	24.70%	1.01%	38.62%
1990	8.96%	1.05%	24.66%	0.99%	38.47%
1991	8.56%	1.07%	24.35%	0.92%	44.63%
1992	8.14%	1.10%	24.78%	0.96%	48.98%
1993	8.27%	1.06%	25.55%	0.98%	45.78%
1994	8.35%	1.08%	26.62%	1.04%	38.55%
1995	9.64%	1.04%	26.19%	1.06%	41.78%
1996	9.40%	0.98%	26.77%	1.10%	43.68%
1997	9.43%	0.68%	25.78%	1.19%	45.42%
1998	9.85%	0.60%	26.54%	1.32%	49.80%
1999	10.45%	0.71%	25.48%	1.43%	53.48%
2000	10.85%	0.61%	27.05%	1.53%	56.16%
2001	10.91%	0.58%	24.96%	1.56%	99.65%
2002	10.77%	0.64%	25.92%	1.44%	89.68%
2003	10.82%	0.64%	25.57%	1.39%	76.81%
2004	10.91%	0.59%	25.80%	1.43%	55.33%
2005	11.11%	0.50%	26.05%	1.44%	61.89%
2006	11.19%	0.47%	26.39%	1.52%	54.86%
2007	11.13%	0.44%	25.92%	1.69%	50.54%
2008	11.04%	0.42%	26.45%	1.69%	56.14%
Avg	**8.64%**	**2.69%**	**23.00%**	**1.01%**	**33.86%**

We need to calculate the tax rate on consumption, import, labour, capital and income in order to obtain a breakdown of taxes paid on the various outputs and inputs in our model and making due adjustments. From the OECD database the following tax data were obtained and their relevance is also provided:

T1000: These are taxes on income, profit and capital gains;

T1100: These are taxes on individuals (regarded as a tax on labour services); 1100 of individuals

T2000: These are social security contributions (tax on labour)

T3000: These are taxes on payrolls and the workforce (tax on labour)

T4000: These are taxes on property (tax on capital)

T5000: These are taxes on goods and services (taxes on C+I)

T5123: These are customs and import duties (taxes on imports)

T5124: These are taxes on exports 5124

Here it is assumed that there is no tax on investment or government. On the basis of the aforesaid data following tax amount is calculated: Tax on Consumption is (T5000-T5123-T5124), Tax on import is T5123, tax on labour is (T1100+T2000+T3000) and finally on Capital it is (T1000-T1100+T4000). By dividing these absolute tax amount by value of consumption, capital, import, labour we obtain the tax rate. Tax rate on labour and income remain by far the highest. Switzerland has one of the lowest capital tax rates and it is evident here. Tax rate on income in 2001-2003 periods is very high but McDaniel (2007) found similar rate for UK, although using slightly different methodology.

For instance McDaniel included subsidies in his calculation which was neglected in this case as some subsidies fall on outputs and hence should be treated as an offset to a commodity tax on output. Then there are those which are independent of outputs produced and hence should be regarded as an offset to taxes on capital. Since the breakdown of subsidies into these two categories is not available, they are neglected here. In order to calculate the tax on income, the author calculated the gross return to capital using the producer prices. Following equation was used: (TRX = 0)

Gross Profit =PC*(1-TRC)*QC+PI*QI+PG*QG+PX*(1-TRX)*QX-PM*(1+TRM)*QM-PL*QL

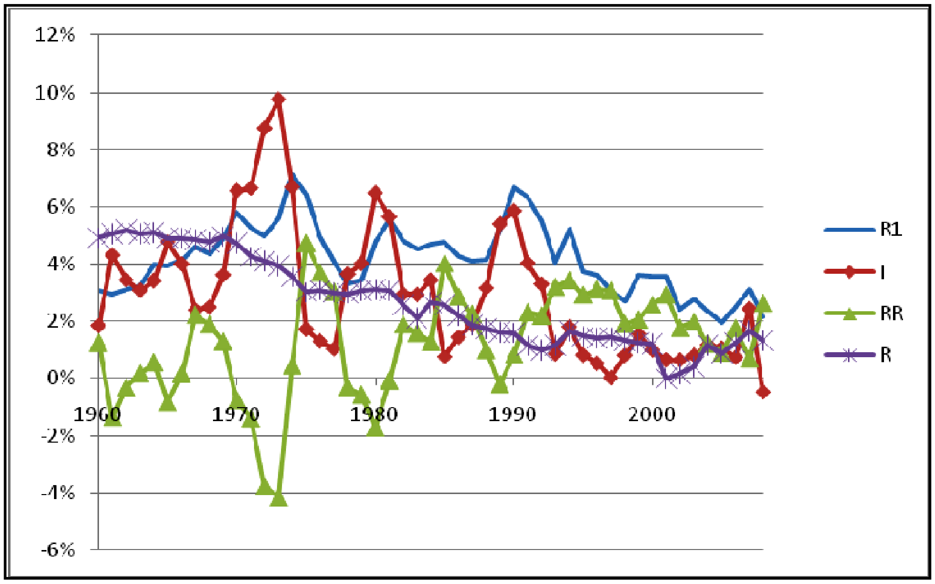
Then the value of depreciation allowances was subtracted from gross profits, in order to obtain net profits or net income before taxes. Thus income tax rate (TRKI) is simply tax on capital by net profit. Even though Swiss economy was deeply affected by 911 bombing, it still seems rather interesting that income tax should be so high during those periods. One argument is that even though you continue to pay similar tax (depreciation are rather stable) your capital income may fall drastically, thus skyrocketing the implicit tax rate. Even then rate during the 3 year period does seem bit too high. Next we look at the interest rate.

The following table 7 provides all the relevant interest rate. R1 is the Nominal Interest Rate (Government bond yield). The inflation rate I is the ex post annual CPI inflation rates. The ex post real interest rate RR series is calculated by subtracting R1 from the ex post CPI inflation rate. Then in accordance with Diewert, we calculate real (after tax) rates of return that cause the value of inputs to equal the value of outputs. A simplified user cost formula is PI(R+D)K+TK= value of output - value of labour = GPROF, where R is a real return. If we have constant returns to scale and competitive pricing, GPROF should equal the value of capital services. The aforesaid equation can be rearranged to the following equation: R = ((GPROF-TK)/PI*K)-D. where R should be around 2% to 5% on average for the economy.

We see from the following figure that during the Oil shocks in 1970s and to a smaller degree in 80s, inflation increased rapidly. It is because of this rising inflation we see that during those periods real interest rate RR was really low or even negative. It is noteworthy that the value of R shows a singular decreasing trend. Although the average is within the accepted range but it does seem low in the later periods. Here also we see that during the early 2000 the value of R is very low. This might be due to rapidly increasing capital stock and depreciation rate and lowering of gross profit. Even so it does look rather low.

Table 7: Rates of Return				
YEAR	R1	I	RR	R
1960	3.090%	1.845%	1.245%	4.924%
1961	2.960%	4.316%	-1.356%	5.057%
1962	3.130%	3.440%	-0.310%	5.179%
1963	3.250%	3.081%	0.169%	5.053%
1964	3.970%	3.414%	0.556%	5.104%
1965	3.950%	4.776%	-0.826%	4.913%
1966	4.160%	4.005%	0.155%	4.888%
1967	4.610%	2.396%	2.214%	4.850%
1968	4.370%	2.489%	1.881%	4.770%
1969	4.900%	3.616%	1.284%	4.960%
1970	5.820%	6.573%	-0.753%	4.744%
1971	5.270%	6.660%	-1.390%	4.258%
1972	4.970%	8.755%	-3.785%	4.109%
1973	5.600%	9.767%	-4.167%	3.933%
1974	7.150%	6.697%	0.453%	3.551%
1975	6.440%	1.715%	4.725%	3.008%
1976	4.990%	1.296%	3.694%	3.086%
1977	4.050%	1.029%	3.021%	3.001%
1978	3.330%	3.648%	-0.318%	2.960%
1979	3.450%	4.023%	-0.573%	3.067%
1980	4.770%	6.490%	-1.720%	3.107%
1981	5.570%	5.655%	-0.085%	3.070%
1982	4.832%	2.950%	1.883%	2.576%
1983	4.515%	2.931%	1.584%	2.115%
1984	4.702%	3.435%	1.267%	2.651%
1985	4.777%	0.750%	4.026%	2.583%
1986	4.293%	1.440%	2.853%	2.188%
1987	4.117%	1.872%	2.245%	1.871%
1988	4.148%	3.155%	0.993%	1.730%
1989	5.198%	5.404%	-0.206%	1.603%
1990	6.680%	5.860%	0.820%	1.590%
1991	6.350%	4.037%	2.313%	1.143%
1992	5.480%	3.293%	2.187%	0.996%
1993	4.050%	0.852%	3.198%	1.156%
1994	5.230%	1.800%	3.430%	1.658%
1995	3.730%	0.812%	2.918%	1.476%
1996	3.630%	0.520%	3.110%	1.416%
1997	3.080%	0.018%	3.062%	1.435%
1998	2.710%	0.806%	1.904%	1.334%
1999	3.620%	1.559%	2.061%	1.245%
2000	3.550%	0.989%	2.561%	1.198%
2001	3.560%	0.643%	2.917%	0.005%
2002	2.400%	0.638%	1.762%	0.166%
2003	2.780%	0.803%	1.977%	0.420%
2004	2.380%	1.172%	1.208%	1.153%
2005	1.960%	1.059%	0.901%	0.887%
2006	2.490%	0.732%	1.758%	1.254%
2007	3.110%	2.426%	0.684%	1.650%
2008	2.150%	-0.480%	2.630%	1.324%
Avg	4.190%	2.962%	1.228%	2.662%

Figure 7: Trend in Interest Rate & Inflation

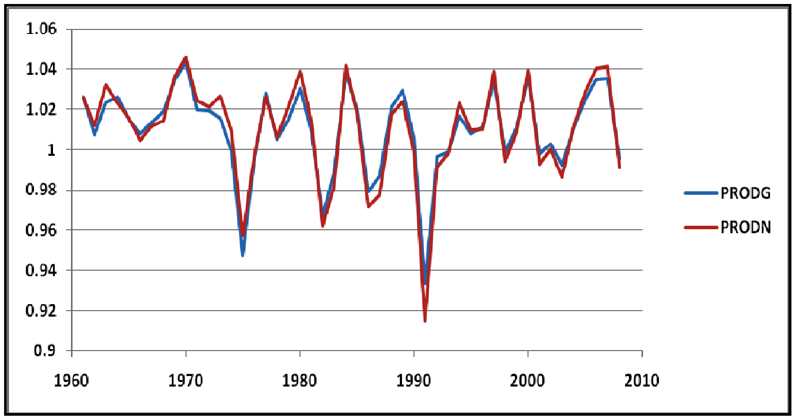


If we use K2 and DRATE2 for the aforesaid calculation then the average Internal Real Rate becomes 0.76% with almost all the figures between 1980-2005 negative. This seems highly unlikely even though Switzerland went through 2 major recessions during that period. Thus even with all the caveats, we intend to use K and DRATE for our relevant estimations. Finally we have all the necessary data to compute the Gross and Net productivity, which we compute next.

In order to calculate productivity, we need to find out the quantity and price of capital service (QKS, PKS). We first estimate gross user cost U of capital, defined as U=PI(D+R+TK). PKS is defined as user cost normalized to 1960 i.e. [U/U(1960)], while QKS is product of capital and base user cost (1960). Using the price and quantity of labour and these capital prices and quantity we develop the chain fisher input aggregate (XG). Similarly we develop output aggregate (YG) using tax adjusted prices and quantity output vectors.

Table 8 : TFP Growth							
	Gross				Net		
YEAR	PRODG	YG	XG	TOFT	PRODG	YG	XG
1961	1.0262	1.0740	1.0466	1.0143	1.0259	1.0763	1.0492
1962	1.0073	1.0468	1.0392	1.0369	1.0121	1.0510	1.0385
1963	1.0234	1.0488	1.0248	1.0421	1.0321	1.0539	1.0212
1964	1.0264	1.0540	1.0269	1.0620	1.0229	1.0470	1.0236
1965	1.0148	1.0299	1.0149	1.0717	1.0155	1.0244	1.0087
1966	1.0079	1.0227	1.0147	1.0892	1.0049	1.0146	1.0097
1967	1.0133	1.0309	1.0173	1.1118	1.0115	1.0251	1.0135
1968	1.0188	1.0366	1.0175	1.1335	1.0143	1.0283	1.0138
1969	1.0343	1.0574	1.0224	1.1150	1.0365	1.0575	1.0202
1970	1.0436	1.0660	1.0215	1.0858	1.0461	1.0658	1.0189
1971	1.0197	1.0448	1.0246	1.1128	1.0242	1.0456	1.0209
1972	1.0192	1.0377	1.0182	1.1443	1.0210	1.0340	1.0127
1973	1.0157	1.0301	1.0142	1.1227	1.0265	1.0350	1.0083
1974	0.9994	1.0054	1.0060	1.0755	1.0091	1.0076	0.9985
1975	0.9475	0.9280	0.9794	1.1359	0.9573	0.9258	0.9671
1976	0.9959	0.9843	0.9884	1.1846	0.9979	0.9797	0.9818
1977	1.0282	1.0265	0.9983	1.1441	1.0264	1.0208	0.9946
1978	1.0051	1.0122	1.0071	1.2225	1.0062	1.0116	1.0054
1979	1.0148	1.0249	1.0099	1.1692	1.0210	1.0295	1.0083
1980	1.0302	1.0490	1.0183	1.1042	1.0390	1.0568	1.0171
1981	1.0087	1.0277	1.0188	1.0904	1.0138	1.0304	1.0164
1982	0.9672	0.9754	1.0085	1.1466	0.9622	0.9667	1.0047
1983	0.9882	0.9905	1.0024	1.1689	0.9816	0.9801	0.9985
1984	1.0381	1.0426	1.0043	1.1724	1.0417	1.0433	1.0015
1985	1.0199	1.0383	1.0180	1.1489	1.0177	1.0350	1.0170
1986	0.9792	0.9973	1.0185	1.2545	0.9719	0.9891	1.0177
1987	0.9868	1.0092	1.0227	1.3050	0.9771	0.9996	1.0230
1988	1.0210	1.0462	1.0247	1.2759	1.0175	1.0434	1.0255
1989	1.0293	1.0482	1.0184	1.2442	1.0241	1.0416	1.0171
1990	1.0060	1.0329	1.0267	1.2639	0.9994	1.0263	1.0268
1991	0.9336	0.9869	1.0571	1.2906	0.9152	0.9744	1.0647
1992	0.9965	0.9994	1.0029	1.2760	0.9914	0.9902	0.9988
1993	0.9990	0.9951	0.9961	1.3205	0.9978	0.9903	0.9924
1994	1.0168	1.0142	0.9974	1.3760	1.0230	1.0176	0.9947
1995	1.0081	1.0046	0.9965	1.4090	1.0096	1.0020	0.9924
1996	1.0111	1.0067	0.9956	1.3984	1.0101	1.0010	0.9910
1997	1.0344	1.0277	0.9935	1.3578	1.0392	1.0278	0.9890
1998	0.9988	1.0190	1.0203	1.3766	0.9942	1.0159	1.0219
1999	1.0107	1.0290	1.0182	1.3665	1.0083	1.0272	1.0188
2000	1.0358	1.0434	1.0074	1.3298	1.0393	1.0453	1.0058
2001	0.9980	0.9980	0.9999	1.3267	0.9930	0.9893	0.9963
2002	1.0031	1.0028	0.9997	1.3758	1.0004	0.9975	0.9971
2003	0.9925	0.9999	1.0075	1.4029	0.9864	0.9936	1.0073
2004	1.0113	1.0282	1.0167	1.3938	1.0122	1.0316	1.0191
2005	1.0249	1.0278	1.0028	1.3606	1.0286	1.0301	1.0015
2006	1.0349	1.0462	1.0110	1.3450	1.0406	1.0525	1.0114
2007	1.0352	1.0530	1.0172	1.3423	1.0413	1.0606	1.0186
2008	0.9955	1.0205	1.0251	1.3350	0.9912	1.0187	1.0278
Avg	1.0099	1.0234	1.0133	1.2215	1.0100	1.0211	1.0110

Figure 8: Trend in Productivity Growth



From the table it becomes obvious that indeed in terms of both net and gross estimate, the productivity performance of Switzerland has been less than stellar. But as before we see that the terms of trade do show significant improvement consistent with Kohli(2003) and Ruhl and Kehoe (2005). In the following tables we see the average performance in 10 year interval time period.

Table 9: Gross Average TFP Growth				
Period	PRODG	YG	XG	TOFT
1961-1970	1.0216	1.0467	1.0246	1.0762
1971-1980	1.0076	1.0143	1.0064	1.1416
1981-1990	1.0044	1.0208	1.0163	1.2071
1991-2000	1.0045	1.0126	1.0085	1.3501
2001-2008	1.0119	1.0221	1.0100	1.3603
1961-2008	1.0099	1.0234	1.0133	1.2215

Table 10: Net Average TFP Growth			
Period	PRODG	YG	XG
1961-1970	1.0222	1.0444	1.0217
1971-1980	1.0129	1.0146	1.0015
1981-1990	1.0007	1.0155	1.0148
1991-2000	1.0028	1.0092	1.0069
2001-2008	1.0117	1.0218	1.0099
1961-2008	1.0100	1.0211	1.0110

The aforesaid table 9 and 10 does seem interesting. In terms of productivity it is obvious that the golden periods were the 1960s and this is pretty much similar to all other OECD countries. The 70s, 80s and 90s were dismal for the Swiss Economy. As Diewert (2005) mentions that there are two broad approaches to measuring TFP measurement, namely the growth accounting or index number approach and the econometric estimation approach. In this paper the index number approach was used but most other researchers have used the econometric method which basically focuses on the Solow residual as a measurement of TFP. However what is interesting to note is how similar these findings are. For instance Kohli (2004) finds that average TFP growth in 1981-1990 was 0.446% and in 1991-2000 it was 0.469% which are very close to Table 9 estimates for the same period, which are 0.44% and 0.45% respectively for the same periods. Also Gagales (2002) in IMF study on Swiss productivity find the TFP to be 0.5% for the both the periods mentioned above. Hence the finding of this paper does seem congruent to general findings in other papers using different methodology. Also both Kohli and Gagales find average Swiss TFP growth to be 0.9%, which is close to our estimate of 0.99% ; considering they didn't include the 60s and late 00s, which had high TFP growth, it is understandable that their estimates is likely to be lower than ours.

It is interesting to note that TFP has started increasing rapidly after 2003 but after the global financial crisis it might be tapping out. If we look at Table 9, we also see that TOFT has shown a singular increasing trend over the decades and this might answer the Swiss Paradox that even with such dismal productivity performance, it still has such a high living standard. As Kohli puts it, a higher TOFT implies for a given trade balance position, the country can either import for what it exports, or export less for what it imports, in other words it can get more for less. Juxtapose this with high initial relative living standard and we can understand the Swiss paradox of low growth performance simultaneously cohabiting with high living standards.

Now we turn now to a more theoretical framework where we will be able to determine the factors that explain real income growth in the Swiss economy. This section is adapted from Diewert, Mizobuchi and Nomura (2005), Diewert and Lawrence (2006).

4. The Translog GDP function approach and real income growth decomposition

This section is a brief outline on the Translog function and production theoretic framework developed by Diewert (1983), Diewert and Morrison (1986), Morrison and Diewert (1990), Diewert and Lawrence (2005) and Kohli (1990) (1991) (2003) (2004a) (2004b). Present author takes no credit in the development of the methodology and hence the section is provided only for the purpose of elucidation. Interested readers are suggested to look in to the aforesaid references for further details.

First we assume that the economy produces quantities of M (net) outputs [in case of import we use negative sign] , $y = [y_1 ,...,y_M]$, which are sold at the positive producer prices $P = [P_1 ,...,P_M]$. We further assume that the market sector of the economy uses positive quantities of N primary inputs, $x = [x_1 ,...,x_N]$ which are purchased at the positive primary input prices $W = [W_1 ,...,W_N]$. In period t, we assume that there is a feasible set of output vectors y that can be produced by the market sector if the vector of primary inputs x is utilised by the market sector of the economy; denote this period t production possibilities set by S_t . Given a vector of output prices P and a vector of available primary inputs x, we define the period t market sector GDP function, $g^t (P,x)$, as follows:

$$g^t(P,x) \equiv \max_y \{P\cdot y : (y,x) \text{ belongs to } S^t\} ; \qquad t = 0,1,2, \ldots .$$

The aforesaid function is linearly homogeneous and convex in the components of P and linearly homogeneous and concave in the components of x. Since market sector GDP is distributed to the factors of production used by the market sector, nominal market sector GDP will be equal to nominal market sector income; i.e. we have $g^t(P^t,x^t) = P^t\cdot y^t = W^t\cdot x^t$. We will choose to measure the real income generated by the market sector, as an approximate welfare measure that can be associated with market sector production, in period t, r_t , in terms of the number of consumption bundles that the nominal income could purchase in period t; i.e. define ρ^t as follows:

$$\begin{aligned} \rho^t &\equiv W^t\cdot x^t/P_C{}^t ; \qquad t = 0,1,2, \ldots \\ &= w^t\cdot x^t \\ &= p^t\cdot y^t \\ &= g^t(p^t,x^t) \end{aligned}$$

Where $p_c^t > 0$ is the period t consumption expenditures deflator and the market sector period t real output price p^t and real input price w^t vectors are defined as the corresponding nominal price vectors deflated by the consumption expenditures price index. The aforesaid equation implies that period t real income, ρ^t, is equal to the period t GDP function, evaluated at the period t real output price vector p^t and the period t input vector x^t, $g^t(p^t, x^t)$. So the growth in real income over time can be explained by three main factors: t - Total Factor Productivity growth), growth in real output prices and the growth of primary inputs, which is essentially the real income decomposition we are looking for.

Now in accordance with Diewert and Morrison (1986; 663) the author assumes that the log of the period t (deflated) GDP function, $g^t(p,x)$, has the following Translog functional form:

$$\begin{aligned} \ln g^t(p,x) \equiv a_0^t + \textstyle\sum_{m=1}^M a_m^t \ln p_m^t + (1/2) \sum_{m=1}^M \sum_{k=1}^M a_{mk} \ln p_m^t \ln p_k^t \\ + \textstyle\sum_{n=1}^N b_n^t \ln x_n^t + (1/2) \sum_{n=1}^N \sum_{j=1}^N b_{nj} \ln x_n^t \ln x_j^t + \sum_{m=1}^M \sum_{n=1}^M c_{mn} \ln p_m^t \ln x_n^t ; \\ t = 0,1,2, \ldots . \end{aligned}$$

The coefficients must satisfy the following restrictions in order for g^t to satisfy the linear homogeneity properties that we have assumed before, although there are additional restrictions on the parameters which are necessary to ensure that $g^t(p,x)$ is convex in p and concave in x.

$$\begin{aligned} &\textstyle\sum_{m=1}^M a_m^t = 1 \text{ for } t = 0,1,2, \ldots; \\ &\textstyle\sum_{n=1}^N b_n^t = 1 \text{ for } t = 0,1,2, \ldots; \\ &a_{mk} = a_{km} \text{ for all } k,m ; \\ &b_{nj} = b_{jn} \text{ for all } n,j ; \\ &\textstyle\sum_{k=1}^M a_{mk} = 0 \text{ for } m = 1,\ldots,M ; \\ &\textstyle\sum_{j=1}^N b_{nj} = 0 \text{ for } n = 1,\ldots,N ; \\ &\textstyle\sum_{n=1}^N c_{mn} = 0 \text{ for } m = 1,\ldots,M ; \\ &\textstyle\sum_{m=1}^M c_{mn} = 0 \text{ for } n = 1,\ldots,N . \end{aligned}$$

Next we define a family of period t productivity growth factors or technical progress shift factors $\tau(p,x,t)$:

$$\tau(p,x,t) \equiv g^t(p,x)/g^{t-1}(p,x) ; \qquad t = 1,2, \ldots .$$

$\tau(p,x,t)$ measures the proportional change in the real income produced by the market sector at the reference real output prices p and reference input quantities used x. The numerator in the above equation uses the period t technology and the denominator uses the period t−1 technology. Thus each choice of reference vectors p and x will generate a possibly different measure of the shift in technology going from period t−1 to period t. Here we are using the chain system to measure the shift in technology. It is natural to choose special reference vectors for the measure of technical progress but the question is which; since there is no preferential way of choosing the reference point, Diewert etal use the fisher index in the sense they take the geometric average of the Laspeyres and Paasche type measure. Based on this the following equation is developed:

$$\tau^t \equiv [\tau_L{}^t \tau_P{}^t]^{1/2} \; ; \qquad t = 1,2, \ldots .$$

Next we define defining theoretical indexes for the effects on real income due to changes in real output prices. Define a family of period t real output price growth factors $\alpha(p^{t-1},p^t,x,s)$:

$$\alpha(p^{t-1},p^t,x,s) \equiv g^s(p^t,x)/g^s(p^{t-1},x) \; ; \qquad s = 1,2, \ldots .$$

Thus $\alpha(p^{t-1},p^t,x,s)$ measures the proportional change in the real income produced by the market sector that is induced by the change in real output prices going from period t−1 to t, using the technology that is available during period s and using the reference input quantities x. Now like before each choice of the reference technology s and the reference input vector x will generate a possibly different measure of the effect on real income of a change in real output prices going from period t−1 to period t. Thus we need to choose a reference point and as before since they are both equally valid we take the geometric average and get the following equation:

$$\alpha^t \equiv [\alpha_L{}^t \alpha_P{}^t]^{1/2} \; ; \qquad t = 1,2, \ldots .$$

Where L and P subscript stands for Laspeyres and Paasche type measure respectively. Lastly we look at defining theoretical indexes for the effects on real income due to changes in real output prices. Define a family of period t real input quantity growth factors $\beta(x^{t-1},x^t,p,s)$:

$$\beta(x^{t-1},x^t,p,s) \equiv g^s(p,x^t)/g^s(p,x^{t-1}) \; ; \qquad s = 1,2, \ldots .$$

It measures the proportional change in the real income produced by the market sector that is induced by the change in input quantities used by the market sector going from period t−1 to t, using the technology that is available during period s and using the reference real output prices p. Similarly we take the geometric mean of the Laspeyres and Paasche type measure to get the following index:

$$\beta^t \equiv [\beta_L{}^t \beta_P{}^t]^{1/2} ; \qquad t = 1,2, \ldots .$$

Now define γ^t as the period t chain rate of growth factor for real income:

$$\gamma^t \equiv \rho^t/\rho^{t-1} ; \qquad t = 1,2, \ldots .$$

Diewert etal then showed that γ^t and the technology, output price and input quantity growth factors $\tau(p,x,t)$, $\alpha(p^{t-1},p^t,x,s)$, $\beta(x^{t-1},x^t,p,s)$ defined previously satisfy some interesting identities, which are shown below:

$$\begin{aligned} \gamma^t &\equiv \rho^t/\rho^{t-1} ; \qquad t = 1,2, \ldots . \\ &= g^t(p^t,x^t)/g^{t-1}(p^{t-1},x^{t-1}) \\ &= [g^t(p^t,x^t)/g^{t-1}(p^t,x^t)][g^{t-1}(p^t,x^t)/g^{t-1}(p^{t-1},x^t)][g^{t-1}(p^{t-1},x^t)/g^{t-1}(p^{t-1},x^{t-1})] \\ &= \tau_P{}^t\, \alpha(p^{t-1},p^t,x^t,t-1)\, \beta_L{}^t \end{aligned}$$

In similar way they were able to show that, $\gamma^t \equiv \tau_L{}^t\, \alpha(p^{t-1},p^t,x^{t-1},t)\, \beta_P{}^t$. Now if we multiply the two results of γ^t and take the positive square root of that product we get the following:

$$\gamma^t \equiv \tau^t\, [\alpha(p^{t-1},p^t,x^t,t-1)\alpha(p^{t-1},p^t,x^{t-1},t)]^{1/2}\, \beta^t ; \qquad t = 1,2, \ldots .$$

In similar way an alternative decomposition is possible:

$$\gamma^t \equiv \tau^t\, \alpha^t\, [\beta(x^{t-1},x^t,p^t,t-1)\beta(x^{t-1},x^t,p^{t-1},t)]^{1/2} ; \qquad t = 1,2, \ldots .$$

Now we can make the following approximation to equate the input and output growth factors to the aforesaid equations:

$$\begin{aligned} &[\alpha(p^{t-1},p^t,x^t,t-1)\alpha(p^{t-1},p^t,x^{t-1},t)]^{1/2} \approx \alpha^t ; \qquad t = 1,2, \ldots ; \\ &[\beta(x^{t-1},x^t,p^t,t-1)\beta(x^{t-1},x^t,p^{t-1},t)]^{1/2} \approx \beta^t ; \qquad t = 1,2, \ldots . \end{aligned}$$

Using these aforementioned equations we get the following approximate decompositions for the growth of real income into explanatory factors:

$$\gamma^t \approx \tau^t\, \alpha^t\, \beta^t ; \qquad t = 1,2, \ldots$$

where τ^t is a technology growth factor, α^t is a growth in real output prices factor and β^t is a growth in primary inputs factor.

Diewert etal suggest that it is sometimes convenient to express the level of real income in period t in terms of an index of the technology level or of Total Factor Productivity in period t, T^t, of the level of real output prices in period t, A^t, and of the level of primary input quantities in period t, B^t. Thus we use the growth factors τ^t, α^t and β^t as follows to define the levels T^t, A^t and B^t:

$$
\begin{aligned}
&T^0 \equiv 1 \; ; T^t \equiv T^{t-1} \tau^t ; \; t = 1,2, \ldots ; \\
&A^0 \equiv 1 \; ; A^t \equiv A^{t-1}\alpha^t ; t = 1,2, \ldots ; \\
&B^0 \equiv 1 \; ; B^t \equiv B^{t-1}\beta^t \; ; t = 1,2, \ldots .
\end{aligned}
$$

Using the approximate inequality mentioned before they show : $\rho^t/\rho^0 \approx T^t A^t B^t$; Diewert etal showed that under the Translog formulation, mentioned before, the above inequality holds with exact identity. Also, Diewert and Morrison (1986; 663-665) showed that under the Translog functional form τ^t, α^t and β^t could be calculated using empirically observable price and quantity data for periods t−1 and t as follows:

$$
\begin{aligned}
\ln\alpha^t &= \textstyle\sum_{m=1}^{M} (1/2)[(p_m^{t-1} y_m^{t-1}/p^{t-1}\cdot y^{t-1}) + (p_m^t y_m^t/p^t\cdot y^t)] \ln(p_m^t/p_m^{t-1}) \\
&= \ln P_T(p^{t-1},p^t,y^{t-1},y^t); \\
\ln\beta^t &= \textstyle\sum_{n=1}^{N} (1/2)[(w_n^{t-1} x_n^{t-1}/w^{t-1}\cdot x^{t-1}) + (w_n^t x_n^t/w^t\cdot x^t)] \ln(x_n^t/x_n^{t-1}) \\
&= \ln Q_T(w^{t-1},w^t,x^{t-1},x^t); \\
\tau^t &= \gamma^t/\alpha^t \beta^t
\end{aligned}
$$

The T subscript stands for Törnqvist output and price index. Finally they were able to show that with the above setup aggregate real output price contribution factor α^t at time t could be decomposed into a product of separate price contribution factors $\alpha^t = \alpha_1^t \alpha_2^t \ldots\ldots \alpha_M^t$. The three main output being :

- Domestic sales (C+I+G);
- Exports (X) and
- Imports (M)

Similarly Diewert etal showed that there exists an exact decomposition of the period t aggregate input growth contribution factor β^t into a product of separate input quantity contribution factors; The exact decomposition being : $\beta^t = \beta_1^t \beta_2^t \ldots\ldots \beta_M^t$. Thus in the next section, using this theoretical framework we decompose real income in to the aforesaid components.

5. Contribution to Real Income Growth (PROD)

Table 11 : Decomposition of Real Income Growth (Gross)								
YEAR	RLINK	TLINK	PDLINK	PXLINK	PMLINK	QLLINK	QKLINK	PTLINK
1961	1.1005	1.0263	1.0153	0.9982	1.0110	1.0313	1.0149	1.0092
1962	1.0669	1.0074	1.0066	0.9964	1.0162	1.0203	1.0185	1.0126
1963	1.0701	1.0234	1.0145	1.0009	1.0048	1.0059	1.0188	1.0057
1964	1.0705	1.0264	1.0053	1.0010	1.0093	1.0079	1.0189	1.0103
1965	1.0335	1.0148	0.9961	0.9955	1.0119	0.9953	1.0197	1.0074
1966	1.0240	1.0079	0.9953	0.9991	1.0069	0.9980	1.0167	1.0060
1967	1.0306	1.0133	0.9938	0.9973	1.0088	1.0021	1.0152	1.0060
1968	1.0419	1.0188	0.9986	1.0017	1.0048	1.0026	1.0149	1.0065
1969	1.0558	1.0343	1.0028	0.9957	1.0000	1.0084	1.0139	0.9957
1970	1.0826	1.0436	1.0198	1.0035	0.9924	1.0071	1.0143	0.9959
1971	1.0662	1.0197	1.0112	0.9902	1.0191	1.0074	1.0171	1.0092
1972	1.0558	1.0192	1.0085	0.9930	1.0160	1.0010	1.0171	1.0089
1973	1.0216	1.0156	0.9960	0.9857	1.0101	0.9982	1.0160	0.9957
1974	0.9824	0.9994	0.9888	1.0076	0.9808	0.9906	1.0155	0.9883
1975	0.9246	0.9474	0.9806	0.9876	1.0288	0.9656	1.0142	1.0161
1976	0.9844	0.9959	0.9877	0.9904	1.0224	0.9809	1.0076	1.0125
1977	1.0187	1.0282	1.0021	1.0045	0.9859	0.9924	1.0060	0.9903
1978	1.0367	1.0052	1.0035	0.9843	1.0368	1.0017	1.0054	1.0205
1979	1.0006	1.0148	0.9908	0.9934	0.9919	1.0036	1.0063	0.9853
1980	1.0329	1.0303	1.0053	1.0063	0.9732	1.0099	1.0083	0.9794
1981	1.0273	1.0087	1.0041	0.9900	1.0056	1.0079	1.0109	0.9955
1982	0.9915	0.9672	0.9987	0.9893	1.0288	0.9991	1.0094	1.0179
1983	0.9934	0.9882	0.9961	0.9933	1.0136	0.9954	1.0070	1.0068
1984	1.0400	1.0381	0.9957	1.0035	0.9983	0.9985	1.0059	1.0019
1985	1.0310	1.0199	1.0004	0.9977	0.9948	1.0102	1.0078	0.9925
1986	1.0294	0.9792	1.0002	0.9909	1.0415	1.0110	1.0074	1.0320
1987	1.0219	0.9868	0.9984	0.9961	1.0182	1.0157	1.0069	1.0142
1988	1.0450	1.0209	1.0069	1.0008	0.9912	1.0178	1.0068	0.9921
1989	1.0456	1.0293	1.0061	1.0110	0.9806	1.0107	1.0076	0.9914
1990	1.0288	1.0060	0.9908	0.9816	1.0242	1.0183	1.0082	1.0053
1991	0.9822	0.9336	0.9885	0.9878	1.0193	1.0484	1.0083	1.0069
1992	0.9819	0.9965	0.9876	0.9867	1.0083	0.9974	1.0056	0.9949
1993	0.9961	0.9990	0.9898	0.9979	1.0134	0.9929	1.0032	1.0113
1994	1.0215	1.0168	0.9941	0.9975	1.0156	0.9948	1.0027	1.0131
1995	1.0029	1.0081	0.9905	0.9991	1.0087	0.9923	1.0042	1.0079
1996	0.9913	1.0111	0.9883	0.9899	1.0066	0.9910	1.0046	0.9964
1997	1.0078	1.0344	0.9900	0.9998	0.9907	0.9896	1.0040	0.9905
1998	1.0260	0.9988	1.0011	1.0011	1.0046	1.0165	1.0037	1.0057
1999	1.0286	1.0106	1.0032	0.9977	0.9987	1.0137	1.0045	0.9964
2000	1.0403	1.0358	1.0064	1.0121	0.9788	1.0032	1.0042	0.9906
2001	1.0018	0.9980	1.0049	0.9984	1.0005	0.9957	1.0042	0.9989
2002	1.0110	1.0031	0.9949	0.9832	1.0307	0.9971	1.0026	1.0134
2003	1.0038	0.9925	0.9958	1.0011	1.0071	1.0053	1.0021	1.0081
2004	1.0239	1.0113	0.9985	0.9988	0.9985	1.0149	1.0018	0.9973
2005	1.0199	1.0250	1.0021	1.0031	0.9872	1.0004	1.0024	0.9902
2006	1.0430	1.0349	1.0010	1.0078	0.9881	1.0084	1.0026	0.9958
2007	1.0570	1.0352	1.0023	1.0139	0.9877	1.0138	1.0033	1.0015
2008	1.0169	0.9955	1.0000	0.9947	1.0018	1.0210	1.0040	0.9964
Avg	1.0252	1.0099	0.9991	0.9970	1.0057	1.0044	1.0089	1.0026

The terms are explained below:

RLINK = Real Income Growth

TLINK = Productivity Growth

PDLINK = Real Domestic Output Prices Growth

PXLINK = Real Export Prices Growth

PMLINK = Real Import Prices Growth

QLLINK = Labour Input Growth

QKLINK = Capital Input Growth

PTLINK = Real Terms of Trade Growth

Since it is useful to combine the effects of real export and import price change for some purposes Real terms of trade growth is developed using:

```
PTLINK=PXLINK*PMLINK
```

Thus in Switzerland, real income generated by the economy is growing at an average annual rate of 2.52% per year (RLINK). Total factor productivity growth, TLINK, contributes 0.99% per year; note that TLINK is exactly equal to our earlier average fisher rates of TFP growth using gross income, 0.99%/year. Growth in labour input 0.44% per year (QLINK) and growth in capital input 0.89% per year (QKLINK) (this is sometimes called capital deepening). If we combine the effects of changes in import and export prices, then changes in the real terms of trade contributed 0.27% per year to the growth in real income; −0.30% per year due to export prices falling faster than domestic consumption prices and 0.57% per year due to import prices falling faster than domestic consumption prices. Thus the impact of term of trade improvement has been modest if not insignificant, on living standards of Switzerland. It seems the major contributors are productivity growth, followed by capital deepening and finally labour growth.

However the aforesaid analysis is flawed as depreciation payments are part of the user cost of capital for each asset but depreciation does not provide households with any sustainable purchasing power. We can consume the amount of money set aside for depreciation in the short run, but this cannot be sustained in the long term, hence the real income measured above is overstated. This aspect of the overstatement is dealt with in great detail in section 7 of Diewert, Mizobuchi and Nomura (2005). The same methodology (and programs) is used but depreciation is taken out of the user cost of capital and treated as a negative output. Exports, imports and labour variables remain unchanged but capital services is redefine and a new domestic output aggregate is developed. Thus investment aggregate I is a net investment aggregate (gross investment components are indexed with a positive sign in the aggregate and depreciation components are indexed with a negative sign in the aggregate).

In Table 12 We see that our average TLINK is exactly equal to our earlier average fisher rates of TFP growth using net income, 1.00%/year. The average rate of real (net) income growth is 2.48%. Productivity growth is 1.00% per year (TLINK) (up from the gross 0.99% per year), growth of real output prices 0.04% per year (PDLINK) (up from the gross negative per year), can be considered still zero. Changes in real export prices is -0.353% per year (slight change from the gross -0.297% per year) (PXLINK), while change in real import prices 0.70% per year (a bit bigger than the gross 0.57% per year) (PMLINK). We see that changes in the real terms of trade contributed 0.32% per year up from 0.27% in gross estimate. Growth in labour input is 0.54% per year, up from the gross 0.44% per year (QLLINK) and growth in net capital input 0.55% per year, down substantially from the gross 0.89% per annum (QKLINK).Thus compared to our previous results, the role of labour growth has increased substantially, the role of TFP growth has increased a bit and the role of capital accumulation has diminished.

Table 12 : Decomposition of Real Income Growth (Net)								
YEAR	RLINK	TLINK	PDLINK	PXLINK	PMLINK	QLLINK	QKLINK	PTLINK
1961	1.0998	1.0260	1.0105	0.9979	1.0133	1.0378	1.0110	1.0111
1962	1.0727	1.0120	1.0054	0.9957	1.0195	1.0244	1.0137	1.0151
1963	1.0725	1.0320	1.0107	1.0011	1.0058	1.0071	1.0140	1.0069
1964	1.0653	1.0230	1.0050	1.0012	1.0111	1.0095	1.0140	1.0123
1965	1.0306	1.0155	0.9972	0.9945	1.0144	0.9944	1.0144	1.0089
1966	1.0189	1.0049	0.9970	0.9989	1.0083	0.9976	1.0121	1.0072
1967	1.0293	1.0115	0.9967	0.9967	1.0107	1.0026	1.0109	1.0073
1968	1.0365	1.0143	1.0000	1.0021	1.0059	1.0031	1.0106	1.0080
1969	1.0547	1.0365	1.0026	0.9948	1.0000	1.0102	1.0099	0.9948
1970	1.0739	1.0461	1.0128	1.0043	0.9907	1.0087	1.0101	0.9949
1971	1.0672	1.0242	1.0092	0.9880	1.0236	1.0091	1.0117	1.0113
1972	1.0521	1.0210	1.0065	0.9914	1.0197	1.0013	1.0114	1.0110
1973	1.0288	1.0265	0.9993	0.9825	1.0125	0.9978	1.0106	0.9947
1974	0.9865	1.0091	0.9933	1.0093	0.9766	0.9885	1.0101	0.9857
1975	0.9343	0.9573	0.9898	0.9850	1.0352	0.9584	1.0090	1.0196
1976	0.9900	0.9979	0.9955	0.9884	1.0270	0.9771	1.0048	1.0151
1977	1.0096	1.0264	1.0007	1.0055	0.9829	0.9908	1.0038	0.9883
1978	1.0392	1.0063	1.0022	0.9811	1.0447	1.0020	1.0034	1.0249
1979	1.0067	1.0210	0.9955	0.9920	0.9902	1.0044	1.0039	0.9823
1980	1.0337	1.0391	1.0029	1.0076	0.9679	1.0118	1.0052	0.9753
981	1.0274	1.0138	1.0026	0.9880	1.0067	1.0094	1.0069	0.9946
1982	0.9878	0.9622	1.0003	0.9872	1.0348	0.9989	1.0058	1.0216
1983	0.9863	0.9817	0.9981	0.9919	1.0165	0.9945	1.0040	1.0083
1984	1.0433	1.0417	0.9978	1.0043	0.9980	0.9981	1.0034	1.0023
1985	1.0259	1.0177	1.0002	0.9972	0.9937	1.0124	1.0046	0.9910
1986	1.0285	0.9720	1.0006	0.9889	1.0507	1.0134	1.0042	1.0390
1987	1.0158	0.9771	0.9989	0.9952	1.0223	1.0192	1.0037	1.0174
1988	1.0375	1.0175	1.0041	1.0010	0.9892	1.0220	1.0034	0.9903
1989	1.0342	1.0241	1.0035	1.0137	0.9760	1.0133	1.0037	0.9894
1990	1.0286	0.9995	0.9957	0.9771	1.0303	1.0229	1.0038	1.0067
1991	0.9781	0.9152	0.9953	0.9848	1.0242	1.0609	1.0036	1.0086
1992	0.9806	0.9914	0.9967	0.9834	1.0104	0.9967	1.0022	0.9936
1993	1.0009	0.9979	0.9967	0.9973	1.0168	0.9911	1.0013	1.0141
1994	1.0327	1.0230	0.9987	0.9969	1.0194	0.9935	1.0012	1.0163
1995	1.0097	1.0096	0.9981	0.9989	1.0108	0.9905	1.0019	1.0097
1996	0.9917	1.0101	0.9951	0.9876	1.0080	0.9890	1.0020	0.9956
1997	1.0111	1.0393	0.9953	0.9998	0.9886	0.9873	1.0017	0.9884
1998	1.0249	0.9942	1.0018	1.0014	1.0056	1.0202	1.0017	1.0070
1999	1.0241	1.0083	1.0014	0.9972	0.9984	1.0168	1.0020	0.9956
2000	1.0368	1.0394	1.0034	1.0149	0.9740	1.0039	1.0018	0.9885
2001	0.9905	0.9930	1.0026	0.9980	1.0006	0.9947	1.0016	0.9987
2002	1.0133	1.0004	0.9991	0.9791	1.0383	0.9964	1.0008	1.0167
2003	1.0036	0.9864	0.9999	1.0013	1.0088	1.0066	1.0007	1.0101
2004	1.0279	1.0122	0.9997	0.9985	0.9981	1.0185	1.0007	0.9967
2005	1.0191	1.0286	1.0014	1.0038	0.9842	1.0005	1.0010	0.9879
2006	1.0477	1.0406	1.0006	1.0097	0.9853	1.0104	1.0011	0.9948
2007	1.0635	1.0413	1.0010	1.0172	0.9849	1.0171	1.0015	1.0018
2008	1.0147	0.9912	1.0004	0.9935	1.0022	1.0259	1.0018	0.9956
Avg	1.0248	1.0100	1.0004	0.9964	1.0070	1.0054	1.0056	1.0032

The annual change information in the previous table 11 and 12 can be converted into cumulative changes using the following equation (with obvious extensions to multiple inputs and outputs).

$$\rho^t/\rho^0 = T^t A^t B^t \; ; \quad t = 1,2, \dots .$$

This is precisely what we do in the following table 13 and 14. This is essentially Kohli type decomposition of real income into multiplicative effects.

Table 13: Decomposition of Real Income (Gross) in to multiplicative Effects								
YEAR	RI	TT	DD	XX	MM	LL	KK	TTT
1960	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1961	1.1005	1.0263	1.0153	0.9982	1.0110	1.0313	1.0149	1.0092
1962	1.1742	1.0338	1.0219	0.9947	1.0273	1.0522	1.0337	1.0219
1963	1.2565	1.0580	1.0367	0.9956	1.0323	1.0584	1.0532	1.0277
1964	1.3450	1.0859	1.0422	0.9966	1.0419	1.0667	1.0730	1.0383
1965	1.3900	1.1020	1.0382	0.9921	1.0543	1.0617	1.0941	1.0459
1966	1.4235	1.1107	1.0333	0.9912	1.0615	1.0596	1.1125	1.0522
1967	1.4671	1.1255	1.0269	0.9885	1.0709	1.0618	1.1293	1.0585
1968	1.5286	1.1466	1.0255	0.9902	1.0760	1.0646	1.1462	1.0654
1969	1.6139	1.1860	1.0283	0.9860	1.0760	1.0735	1.1621	1.0609
1970	1.7471	1.2377	1.0486	0.9894	1.0678	1.0811	1.1787	1.0565
1971	1.8628	1.2621	1.0604	0.9797	1.0882	1.0891	1.1988	1.0662
1972	1.9668	1.2864	1.0694	0.9729	1.1056	1.0902	1.2193	1.0756
1973	2.0092	1.3065	1.0651	0.9590	1.1168	1.0882	1.2388	1.0710
1974	1.9739	1.3057	1.0532	0.9663	1.0954	1.0780	1.2580	1.0585
1975	1.8250	1.2371	1.0328	0.9543	1.1270	1.0410	1.2759	1.0755
1976	1.7966	1.2320	1.0201	0.9451	1.1522	1.0211	1.2856	1.0890
1977	1.8302	1.2667	1.0223	0.9494	1.1359	1.0134	1.2933	1.0784
1978	1.8974	1.2733	1.0259	0.9345	1.1777	1.0150	1.3003	1.1006
1979	1.8986	1.2922	1.0165	0.9283	1.1682	1.0187	1.3085	1.0844
1980	1.9610	1.3313	1.0219	0.9342	1.1368	1.0287	1.3194	1.0620
1981	2.0145	1.3428	1.0261	0.9248	1.1432	1.0368	1.3338	1.0573
1982	1.9974	1.2988	1.0247	0.9150	1.1762	1.0359	1.3463	1.0762
1983	1.9841	1.2834	1.0207	0.9089	1.1921	1.0312	1.3557	1.0835
1984	2.0635	1.3324	1.0163	0.9121	1.1902	1.0296	1.3636	1.0855
1985	2.1274	1.3589	1.0167	0.9100	1.1840	1.0401	1.3742	1.0774
1986	2.1900	1.3307	1.0168	0.9016	1.2331	1.0515	1.3844	1.1119
1987	2.2379	1.3131	1.0152	0.8981	1.2556	1.0680	1.3940	1.1277
1988	2.3387	1.3406	1.0222	0.8989	1.2446	1.0871	1.4034	1.1187
1989	2.4452	1.3798	1.0284	0.9088	1.2205	1.0987	1.4141	1.1091
1990	2.5156	1.3882	1.0189	0.8921	1.2500	1.1189	1.4257	1.1151
1991	2.4709	1.2959	1.0072	0.8812	1.2741	1.1731	1.4374	1.1227
1992	2.4262	1.2914	0.9947	0.8695	1.2846	1.1699	1.4454	1.1170
1993	2.4166	1.2901	0.9845	0.8676	1.3019	1.1617	1.4501	1.1295
1994	2.4686	1.3118	0.9787	0.8655	1.3222	1.1556	1.4540	1.1444
1995	2.4757	1.3225	0.9695	0.8647	1.3338	1.1467	1.4602	1.1533
1996	2.4542	1.3372	0.9581	0.8560	1.3425	1.1364	1.4669	1.1492
1997	2.4733	1.3832	0.9486	0.8558	1.3300	1.1245	1.4727	1.1383
1998	2.5376	1.3815	0.9496	0.8568	1.3361	1.1430	1.4782	1.1448
1999	2.6101	1.3962	0.9526	0.8548	1.3343	1.1587	1.4849	1.1406
2000	2.7154	1.4462	0.9588	0.8652	1.3060	1.1623	1.4911	1.1299
2001	2.7202	1.4434	0.9635	0.8638	1.3067	1.1573	1.4974	1.1287
2002	2.7500	1.4479	0.9585	0.8493	1.3467	1.1540	1.5013	1.1438
2003	2.7603	1.4370	0.9545	0.8502	1.3562	1.1601	1.5045	1.1531
2004	2.8263	1.4533	0.9530	0.8492	1.3542	1.1774	1.5072	1.1500
2005	2.8826	1.4895	0.9550	0.8518	1.3369	1.1778	1.5109	1.1387
2006	3.0064	1.5414	0.9560	0.8585	1.3210	1.1877	1.5148	1.1340
2007	3.1778	1.5957	0.9582	0.8704	1.3048	1.2041	1.5198	1.1357
2008	3.2314	1.5885	0.9582	0.8658	1.3071	1.2294	1.5259	1.1316

RI = Cumulative Growth Factor for Real Income

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DD = Cumulative Growth Factor for Domestic Real Prices

XX = Cumulative Growth Factor for Export Prices

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TTT = Cumulative Growth Factor for International Trade Prices

Note that real (gross) income grew 3.23 fold over the 49 year period. Growth factor for productivity is 1.58 and growth factor for domestic real prices is 0.95(so real prices fell more than consumption) . Also growth factor for export prices is 0.87 (so export prices fell more than consumption prices)

Growth factor for import prices is 1.31 (so import prices increased 31% relative to the price of c over the 49 years)

Growth factor for labour is 1.23 and growth factor for gross capital services is 1.526 (this is in the "normal" range).

Thus growth of productivity, labour and capital services growth may explain most of the real income growth

Table 14: Decomposition of Real Income (Net) in to multiplicative Effects								
YEAR	**RI**	**TT**	**DD**	**XX**	**MM**	**LL**	**KK**	**TTT**
1960	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1961	1.0998	1.0260	1.0105	0.9979	1.0133	1.0378	1.0110	1.0111
1962	1.1797	1.0383	1.0159	0.9936	1.0330	1.0632	1.0249	1.0264
1963	1.2652	1.0716	1.0268	0.9947	1.0390	1.0707	1.0393	1.0335
1964	1.3478	1.0962	1.0319	0.9959	1.0505	1.0808	1.0538	1.0462
1965	1.3890	1.1132	1.0290	0.9904	1.0657	1.0747	1.0689	1.0555
1966	1.4153	1.1187	1.0260	0.9894	1.0745	1.0721	1.0819	1.0631
1967	1.4567	1.1315	1.0226	0.9861	1.0860	1.0749	1.0937	1.0709
1968	1.5098	1.1477	1.0226	0.9882	1.0924	1.0782	1.1053	1.0794
1969	1.5924	1.1897	1.0253	0.9830	1.0923	1.0892	1.1162	1.0738
1970	1.7102	1.2445	1.0384	0.9872	1.0822	1.0987	1.1275	1.0683
1971	1.8250	1.2746	1.0479	0.9754	1.1077	1.1087	1.1407	1.0804
1972	1.9200	1.3014	1.0547	0.9670	1.1295	1.1101	1.1537	1.0922
1973	1.9753	1.3358	1.0539	0.9500	1.1436	1.1077	1.1659	1.0865
1974	1.9485	1.3480	1.0468	0.9589	1.1168	1.0950	1.1776	1.0709
1975	1.8205	1.2904	1.0361	0.9445	1.1561	1.0494	1.1882	1.0919
1976	1.8023	1.2878	1.0314	0.9335	1.1873	1.0254	1.1939	1.1084
1977	1.8196	1.3217	1.0321	0.9386	1.1671	1.0160	1.1985	1.0955
1978	1.8909	1.3300	1.0344	0.9208	1.2193	1.0180	1.2025	1.1228
1979	1.9036	1.3579	1.0297	0.9135	1.2074	1.0225	1.2072	1.1029
1980	1.9676	1.4110	1.0327	0.9204	1.1686	1.0346	1.2135	1.0756
1981	2.0216	1.4305	1.0353	0.9094	1.1764	1.0444	1.2218	1.0698
1982	1.9969	1.3764	1.0356	0.8977	1.2174	1.0433	1.2289	1.0928
1983	1.9696	1.3511	1.0336	0.8905	1.2374	1.0375	1.2338	1.1019
1984	2.0549	1.4075	1.0313	0.8943	1.2349	1.0355	1.2379	1.1044
1985	2.1081	1.4324	1.0316	0.8918	1.2272	1.0483	1.2436	1.0944
1986	2.1681	1.3923	1.0322	0.8818	1.2894	1.0624	1.2489	1.1371
1987	2.2024	1.3604	1.0310	0.8776	1.3182	1.0828	1.2536	1.1568
1988	2.2850	1.3841	1.0353	0.8785	1.3040	1.1066	1.2579	1.1456
1989	2.3630	1.4175	1.0389	0.8906	1.2727	1.1213	1.2625	1.1334
1990	2.4307	1.4168	1.0344	0.8702	1.3112	1.1470	1.2674	1.1410
1991	2.3775	1.2967	1.0295	0.8570	1.3428	1.2169	1.2719	1.1507
1992	2.3314	1.2855	1.0261	0.8427	1.3568	1.2128	1.2746	1.1434
1993	2.3336	1.2827	1.0227	0.8404	1.3797	1.2021	1.2762	1.1595
1994	2.4100	1.3122	1.0213	0.8379	1.4065	1.1943	1.2777	1.1784
1995	2.4333	1.3249	1.0193	0.8370	1.4216	1.1830	1.2802	1.1898
1996	2.4130	1.3382	1.0143	0.8266	1.4330	1.1700	1.2828	1.1845
1997	2.4398	1.3907	1.0095	0.8264	1.4167	1.1550	1.2850	1.1708
1998	2.5005	1.3827	1.0114	0.8276	1.4246	1.1783	1.2871	1.1790
1999	2.5608	1.3941	1.0128	0.8253	1.4223	1.1981	1.2896	1.1738
2000	2.6550	1.4490	1.0162	0.8375	1.3853	1.2028	1.2920	1.1602
2001	2.6298	1.4389	1.0189	0.8359	1.3862	1.1964	1.2941	1.1587
2002	2.6647	1.4394	1.0180	0.8185	1.4393	1.1921	1.2951	1.1780
2003	2.6743	1.4199	1.0179	0.8196	1.4519	1.2000	1.2959	1.1899
2004	2.7489	1.4372	1.0176	0.8184	1.4492	1.2221	1.2968	1.1859
2005	2.8013	1.4783	1.0191	0.8215	1.4262	1.2227	1.2980	1.1716
2006	2.9350	1.5384	1.0197	0.8294	1.4053	1.2354	1.2994	1.1655
2007	3.1214	1.6018	1.0206	0.8437	1.3841	1.2565	1.3013	1.1677
2008	3.1673	1.5878	1.0211	0.8381	1.3871	1.2890	1.3037	1.1626

RI = Cumulative Growth Factor for Real Income

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The per capita net real income increased 2.141 (compared to 2.184 for the gross income model) fold in Switzerland over the 49 year. We haven't displayed the table here. However this implies a fair increase in living standards. But it is interesting to note that the relative importance of the explanatory factors changes quite a bit between the two income models. The role of capital deepening as a contributor to growth in real income diminishes substantially when we move to the net income from gross estimates.

Next we look at the production side of the economy in greater details.

6. Producer Models: Theoretical Framework

The present section deals in succinctly deals with basic model for estimating producer supply and demand functions. It is based on Diewert and Wales (1992) and Diewert Chapter 9 on index number theory. For greater detail in to the modelling technique and methodology involved here, please refer to the aforesaid references. First we define the variable profit function V(k,p) as V(p,k) ≡ max y {p^T y :k = F(y)}. The function V(p,k) must be linearly homogeneous and convex in p for fixed k. The economy's system of profit maximizing supply and demand functions y(p,k) can be obtained by differentiating V(p,k) with respect to the components of p: (Hotelling's (1932) Lemma). Then we define the unit profit function v(p) as V(p,1), which is basically the gross return to capital we can achieve using one unit of capital. Based on this Diewert etal show that we can develop a Translog unit profit function, v(p) with CRS:

$$\ln v(p) \equiv \alpha_0 + \sum_{i=1}^{N} \alpha_i \ln p_i + (1/2) \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_{ij} \ln p_i \ln p_j$$

Which satisfy the following properties as part of being a flexible functional form (Diewert Chapter 9, Section 2):

$$\gamma_{ij} = \gamma_{ji} \; ; \qquad 1 \le i < j \le N \; ; \qquad \text{(N(N−1)/2 symmetry restrictions)}$$
$$\sum_{i=1}^{N} \alpha_i = 1 \; ; \qquad \text{(1 restriction)}$$
$$\sum_{j=1}^{N} \gamma_{ij} = 0 \; ; \; i = 1,\ldots,N \qquad \text{(N restrictions).}$$

However economy becomes more efficient over time because of technical progress. Thus we generalize the Translog unit profit function defined above to include time trends to try and capture the effects of technical progress. Thus we now define the period t unit profit function v(p,t) as follows:

$$\ln v(p,t) \equiv \alpha_0 + \beta_0 t + \sum_{i=1}^{N} \alpha_i \ln p_i + (1/2) \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_{ij} \ln p_i \ln p_j + \sum_{i=1}^{N} \beta_i t \ln p_i$$

Diewert etal then develop an estimating equation system using all the relevant restrictions, which are:

$$\ln[V^t/p_4^t k^t] = \alpha_0 + \beta_0 t + \sum_{i=1}^{3} \alpha_i \ln(p_i^t/p_4^t) + \sum_{i=1}^{3} \beta_i t \ln(p_i^t/p_4^t) + (1/2)\sum_{i=1}^{3} \gamma_{ii} [\ln(p_i^t/p_4^t)]^2 + \sum_{i=1}^{3} \sum_{j=1;i<j}^{3} \gamma_{ij} \ln(p_i^t/p_4^t)\ln(p_j^t/p_4^t) + e_0^t ; \qquad t = 1,\ldots,T.$$

$$s_i^t \equiv p_i^t y_i^t / V^t = \alpha_i + \sum_{j=1}^{3} \gamma_{ij} \ln(p_j^t/p_4^t) + \beta_i t + e_i^t ; \qquad i = 1,\ldots,3 \; ; \; t = 1,\ldots,T.$$

For greater detail on the derivation please review Chapter 9 on Flexible forms by Diewert, which is available in his website[11]. The aforesaid equation is adapted for PMOD 1 described in the following section. As for PMOD2 which is Translog variable profit functions with CRS and linear splines to model technical progress. In that case the aforesaid system of equations is modified by introducing more than one linear time trend; for instance instead of $\beta_0 t$, we get $\beta_{01}t^1$..... $\beta_{0n}t^n$. Similar adjustments are made in other areas of the equation system.

Thus given econometric estimates for the α_i, β_i and γ_{ij}, which are denoted by α_i^*, β_i^* and γ_{ij}^*, the estimated or fitted shares in period t, s_i^{t*} is developed and is given by:

$$s_i^{t*} \equiv \alpha_i^* + \beta_i^* t + \sum_{j=1}^{N} \gamma_{ij}^* \ln p_j^t \; ; \qquad i = 1,\ldots,N \; ; \; t = 1,\ldots,T.$$

Based on this Diewert etal develop the period t cross elasticities of net supply, e_{ij}^t :

$$e_{ij}^t \equiv \partial \ln y_i(k^t,p^t)/\partial \ln p_j = [s_i^{t*}]^{-1} \gamma_{ij}^* + s_j^{t*} \; ; \qquad i \neq j.$$

Similarly using econometric estimates one can obtain the following formula for the period t own elasticities of net supply, e_{ii}^t, :

$$e_{ii}^t \equiv \partial \ln y_i(k^t,p^t)/\partial \ln p_i = [s_i^{t*}]^{-1} \gamma_{ii}^* + s_i^{t*} - 1 \; ; \qquad i = 1,\ldots,N.$$

In measuring the Technical Progress they define $V(k,p,t) \equiv kv(p,t)$, and then differentiate $V(k,p,t)$ with respect to time t and evaluate the resulting expression at the period t data, which yields:

$$\partial \ln V(k,p,t)/\partial t = \beta_0^* + \sum_{i=1}^{N} \beta_i^* \ln p_i^t \equiv T^t \; ; \qquad t = 1,\ldots,T.$$

Where T^t is the desired measure of technical progress.

PMOD3, as defined in the following section, is a basic Leontief with CRS functions with no substitution between inputs and outputs and linear splines to model technical progress. The rationale for CRS is that when one uses fixed costs or nonconstant returns to scale then one gets absurd result like technical progress are usually way too big while on the other hand, estimates of returns to scale are way too small.

[11] http://faculty.arts.ubc.ca/ediewert/594chmpg.htm

Next Diewert etal develop the normalized quadratic profit function with CRS and linear splines to model technical progress. First they define the production unit's period t variable profit function V(k,p,t) as follows:

$$V(k,p,t) \equiv b^T pk + (1/2)[p^T Bp/\alpha^T p]k + c^T ptk$$

where $b^T \equiv [b_1,...,b_N]$ and $c^T \equiv [c_1,...,c_N]$ are parameter vectors and $B \equiv [b_{ij}]$ is a matrix of parameters. The matrix B needs to satisfy the following restrictions:

I. Matrix B has to be symmetric

II. $Bp^* = 0_N$ for some $p^* >> 0_N$.

Next they define vector of period t normalized prices is defined as $v^t \equiv (\alpha^T p^t)^{-1} p^t$. Finally they develop a system of equations:

$$\begin{aligned}
y_1^t/k^t &= b_1 + c_1 t - b_{12}w_{12}^t - b_{13}w_{13}^t - b_{14}w_{14}^t - (1/2)\, v^{tT}Bv^t\alpha_1 + e_1^t\,; && t = 1,...,T\\
y_2^t/k^t &= b_2 + c_2 t + b_{12}w_{12}^t - b_{23}w_{23}^t - b_{24}w_{24}^t - (1/2)\, v^{tT}Bv^t\alpha_2 + e_2^t\,; && t = 1,...,T\\
y_3^t/k^t &= b_3 + c_3 t + b_{13}w_{13}^t + b_{23}w_{23}^t - b_{34}w_{34}^t - (1/2)\, v^{tT}Bv^t\alpha_3 + e_3^t\,; && t = 1,...,T\\
y_4^t/k^t &= b_4 + c_4 t + b_{14}w_{14}^t + b_{24}w_{24}^t + b_{34}w_{34}^t - (1/2)\, v^{tT}Bv^t\alpha_4 + e_4^t\,; && t = 1,...,T.
\end{aligned}$$

Where $v^T Bv = -[b_{12}(w_{12})^2 + b_{13}(w_{13})^2 + b_{14}(w_{14})^2 + b_{23}(w_{23})^2 + b_{24}(w_{24})^2 + b_{34}(w_{34})^2]$. and

$w_{ij} \equiv v_i - v_j$;

Finally on the basis of this Diewert etal develop measure for elasticity and technical progress pertinent for this functional form. The price elasticity matrices are given by:

$$[e_{ij}^t] \equiv [\partial \ln y_i(k^t,p^t,t)/\partial \ln p_j] = [(p_j^t/y_i^{t*})\partial y_i(k^t,p^t,t)/\partial p_j]\,;$$

While period t, Technical Progress is measured by :

$T^t \equiv \partial \ln V(k^t,p^t,t)/\partial t = p^{tT}c^* k^t/V^{t*}\,; \qquad t = 1,...,T.$ where $V^{t*} \equiv p^{tT}y^{t*}$;.

If the estimated B matrix turns out to be not positive definite, then we can rerun the aforesaid model by replacing B by $B = AA^T$, where A is a lower triangular matrix and satisfies $A^T p^* = 0_N$. These aforesaid models can have splines incorporated in them and this is discussed in greater detail in section 17 chapter 9 Flexible Functional Forms of Diewert.

In the aforesaid formulation we have left the substitution matrix B unchanged over time. Diewert etal showed that, as a result of this the previously discussed functional forms have a built in trend in elasticities. This can be solved by allowing B to change with time. Thus in accordance with Diewert, the author set the matrix B equal to a weighted average of a matrix C (which characterizes substitution possibilities at the beginning of the sample period) and a matrix D (which characterizes substitution possibilities at the end of the sample period). Thus B is defined as follows in terms of C and D and the time variable t:

$$B^{t} = (1 - [t/T])C + [t/T]D \; ; \qquad t = 0,1,2,\ldots,T.$$

Also the correct curvature conditions can be imposed globally by setting C and D equal to the product of UUT and VVT respectively, where U and V are lower triangular matrices; i.e. $C = UU^{T}$ and $D = VV^{T}$; where U and V are lower triangular matrices. We can also impose the following normalizations on the matrices U and V: $U^{T}p^{*} = 0_{N}$; $V^{T}p^{*} = 0_{N}$. In the following section we implement these modelling techniques based on Diewert etal, for the Swiss economy. In first part there is a succinct description of the specific types of model used. For greater detail please review the aforementioned references.

7. Producer Models: Empirical Analysis

A brief description of the different model used in this section is given here. PMOD1 is a Translog variable profit functions with CRS. PMOD2 is a Translog variable profit functions with CRS and linear splines to model technical progress; break points being: 1973 1982 1991 and 2000. PMOD3 is basic Leontief with CRS, no substitution between inputs and outputs and linear splines to model technical progress; break points being: 1968, 1974, 1997 and 2004. PMOD4 is a normalized quadratic profit function with CRS and linear splines to model technical progress (curvature conditions are not imposed) using the same breakpoints as PMOD3. PMOD5 is slightly modified PMOD4, it is normalized quadratic profit function with CRS, but imposing curvature conditions and using linear splines to model technical progress. All the PMODs after three have the same break points.

PMOD6 is a normalized quadratic profit function with CRS, imposing curvature conditions, using linear splines to model technical progress and allowing the substitution matrix to have a linear time trend. Lastly PMOD7 is a normalized quadratic profit function with CRS, imposing curvature conditions, using linear splines to model technical progress, allowing the substitution matrix to have a linear time trend and adjusting for heteroskedasticity. This is essentially PMOD6 but both sides of the equations are divided by K, capital. Table 15 and 16 provides the basic parameter and statistics value for the production function.

Table 15: Technical Progress (PMOD Producer model)						
Year	PMOD1	PMOD2	PMOD3	PMOD4 &5	PROD6	PROD7
1960	2.090%	2.390%	2.042%	2.217%	2.229%	2.066%
1961	2.130%	2.480%	2.025%	2.139%	2.132%	2.001%
1962	2.200%	2.550%	2.041%	2.096%	2.065%	1.966%
1963	2.200%	2.900%	2.109%	2.093%	2.047%	1.955%
1964	2.260%	3.150%	2.169%	2.090%	2.019%	1.938%
1965	2.260%	3.500%	2.269%	2.112%	2.021%	1.945%
1966	2.310%	3.610%	2.308%	2.122%	2.015%	1.945%
1967	2.330%	3.870%	2.360%	2.120%	1.995%	1.927%
1968	2.380%	4.080%	2.402%	2.120%	1.976%	1.906%
1969	2.290%	4.320%	0.909%	1.356%	1.569%	1.717%
1970	2.180%	4.740%	1.061%	1.299%	1.489%	1.619%
1971	2.140%	5.260%	1.334%	1.251%	1.420%	1.538%
1972	2.150%	5.510%	1.507%	1.240%	1.398%	1.513%
1973	2.000%	5.910%	1.701%	1.182%	1.325%	1.435%
1974	1.880%	0.710%	1.866%	1.147%	1.237%	1.312%
1975	2.010%	0.880%	-0.018%	0.327%	0.219%	0.185%
1976	2.120%	1.030%	0.041%	0.349%	0.254%	0.229%
1977	2.000%	1.100%	0.031%	0.314%	0.228%	0.192%
1978	2.130%	1.300%	0.121%	0.325%	0.261%	0.245%
1979	1.960%	1.310%	0.100%	0.286%	0.227%	0.207%
1980	1.770%	1.310%	0.062%	0.238%	0.180%	0.148%
1981	1.690%	1.320%	0.068%	0.217%	0.165%	0.141%
1982	1.810%	1.430%	0.129%	0.241%	0.201%	0.187%
1983	1.830%	-0.120%	0.170%	0.236%	0.206%	0.195%
1984	1.850%	-0.140%	0.188%	0.231%	0.204%	0.186%
1985	1.760%	-0.200%	0.187%	0.203%	0.180%	0.161%
1986	1.990%	-0.250%	0.281%	0.229%	0.218%	0.208%
1987	2.100%	-0.270%	0.318%	0.238%	0.230%	0.223%
1988	2.010%	-0.330%	0.315%	0.211%	0.207%	0.197%
1989	1.930%	-0.370%	0.318%	0.182%	0.179%	0.158%
1990	1.920%	-0.460%	0.348%	0.165%	0.169%	0.154%
1991	2.020%	-0.340%	0.309%	0.209%	0.209%	0.209%
1992	1.950%	2.250%	0.314%	0.194%	0.199%	0.201%
1993	2.060%	2.350%	0.347%	0.206%	0.211%	0.212%
1994	2.180%	2.450%	0.385%	0.214%	0.220%	0.222%
1995	2.220%	2.520%	0.444%	0.189%	0.197%	0.189%
1996	2.160%	2.500%	0.469%	0.163%	0.175%	0.164%
1997	2.050%	2.450%	0.500%	0.117%	0.128%	0.104%
1998	2.100%	2.490%	1.038%	1.291%	1.283%	1.312%
1999	2.060%	2.460%	1.014%	1.258%	1.252%	1.280%
2000	1.970%	2.410%	0.994%	1.177%	1.187%	1.206%
2001	1.900%	5.380%	1.017%	1.076%	1.133%	1.139%
2002	1.970%	5.500%	1.059%	1.071%	1.154%	1.158%
2003	2.050%	5.490%	1.064%	1.104%	1.176%	1.183%
2004	2.060%	5.310%	1.026%	1.128%	2.287%	1.188%
2005	1.950%	5.470%	2.249%	2.226%	2.192%	2.179%
2006	1.910%	5.570%	2.200%	2.157%	2.125%	2.113%
2007	1.910%	5.710%	2.162%	2.099%	2.067%	2.056%
2008	1.880%	5.700%	2.076%	2.014%	1.986%	1.975%
Avg	2.042%	2.616%	1.009%	0.989%	1.009%	0.977%

Table 16: Basic Statistics						
	R-Square				Log Likelihood	
Model	Domestic Output	Export	Import	Labour	Initial	Final
PMOD1	0.9569	0.8747	0.9799	0.9620	-67.39	269.80
PMOD2	0.9847	0.9504	0.9901	0.9801	269.80	341.87
PMOD3	0.9792	0.9953	0.9932	0.7981	-708.15	-328.00
PMOD4	0.9604	0.9937	0.9888	0.8491	-708.34	-295.23
PMOD5	0.9604	0.9937	0.9888	0.8491	-705.33	-295.23
PMOD6	0.9612	0.9946	0.9882	0.8827	-295.23	-279.26
PMOD7	0.6935	0.9825	0.9643	0.9918	419.19	438.02

As expected PMOD 1 and PMOD 2 provides estimates which are far off from the actual technical progress estimates made earlier. As shown in Table 18, the determinant condition for PMOD 4 holds and as a result PMOD 5 provides the same result as PMOD4. From the Table 16 we see that PMOD 4 and 6 provides the best fit, solely based on R-square values. PMOD 7 does poorly in domestic output regression. In terms of estimate for Technical Progress, PMOD 4 and PMOD 6 provides the closest estimate to our previous indexing methodology based estimate of 0.99%. However we must look at the elasticities before one can provide judgement as to the superiority of a specific model. In Table 17 and 18, the results from the curvature and determinant conditions are displayed.

	Table 17: Curvature Conditions					
	PMOD1			PMOD2		
YEAR	DET1	DET2	DET3	DET1	DET2	DET3
1960	66.966	522.066	-6728.634	38.364	-404.146	-1561.358
1961	70.034	585.937	-8937.155	36.229	-547.554	-2113.979
1962	72.885	637.108	-12177.113	33.315	-736.618	-2796.136
1963	74.088	741.469	-13753.675	34.867	-617.660	-2622.131
1964	74.538	810.913	-16007.263	33.649	-593.193	-2682.339
1965	76.477	912.436	-18732.150	35.730	-510.881	-2706.961
1966	76.937	993.946	-20096.253	32.292	-594.777	-3040.896
1967	77.203	1064.656	-21359.916	31.759	-562.151	-3105.200
1968	77.468	1148.519	-22504.013	30.082	-557.350	-3223.773
1969	79.313	1271.124	-21094.535	31.667	-530.421	-3235.196
1970	76.862	1253.804	-16227.920	34.672	-308.064	-2188.509
1971	74.740	1143.972	-16835.906	40.150	-132.707	-1687.691
1972	73.766	1099.220	-18439.290	40.742	-146.194	-2266.113
1973	71.779	1037.126	-15299.504	44.759	-42.853	-1611.285
1974	62.909	851.906	-6623.024	42.234	166.857	902.214
1975	64.190	882.167	-9486.391	40.963	150.558	757.826
1976	66.804	955.792	-13622.439	40.298	135.356	574.647
1977	64.575	922.223	-8627.644	41.030	233.759	1890.044
1978	68.840	1021.905	-16416.807	42.314	213.888	1739.185
1979	67.309	996.804	-10716.124	42.813	267.523	2656.802
1980	62.723	881.367	-4770.715	41.750	297.639	2911.696
1981	62.913	885.788	-4184.111	41.739	296.956	2994.274
1982	64.884	949.603	-6779.802	40.131	277.574	3085.928
1983	65.261	964.242	-7395.055	41.865	299.476	3535.100
1984	63.397	920.204	-5744.544	41.814	309.829	3648.061
1985	62.140	883.282	-3874.728	43.141	313.515	3657.657
1986	66.151	1013.279	-9414.152	44.473	333.979	4510.502
1987	68.839	1112.271	-13102.388	45.349	349.911	5018.100
1988	67.964	1083.244	-9329.502	46.658	349.659	5048.267
1989	63.399	933.913	-4507.645	45.950	309.216	4219.492
1990	64.839	976.282	-5652.524	47.285	304.946	4392.213
1991	72.991	1295.688	-9535.675	47.529	357.849	5371.687
1992	73.927	1328.043	-8091.384	49.132	375.045	6102.956
1993	74.990	1384.232	-9693.829	48.909	395.458	7055.870
1994	77.691	1505.232	-13537.580	49.779	433.103	8729.421
1995	75.638	1405.961	-12312.525	51.185	423.851	9394.863
1996	75.958	1398.926	-10047.428	53.468	422.990	10057.794
1997	71.330	1183.728	-3894.998	54.221	339.890	7883.805
1998	74.824	1313.541	-3849.413	56.055	379.308	9656.573
1999	77.457	1398.806	-2057.835	58.337	397.272	10719.728
2000	72.578	1172.723	1512.435	57.727	289.419	7292.410
2001	67.510	962.356	1754.447	55.992	196.967	4934.125
2002	70.521	1061.431	919.968	57.041	245.140	7239.225
2003	74.979	1217.336	1801.273	57.229	334.867	11054.363
2004	80.643	1426.158	4611.523	56.840	460.091	16276.158
2005	75.140	1159.491	5406.075	55.538	337.022	11349.134
2006	71.933	1012.889	5759.105	53.565	271.349	8879.590
2007	68.770	883.034	5612.624	51.330	203.633	6524.982
2008	69.208	872.272	6117.241	50.324	214.076	7079.644
Avg	70.945	1049.764	-8325.855	44.740	89.865	3516.383

The determinant condition of positive semi definiteness fails for both PMOD1 and PMOD2 but for PMOD4 it is satisfied and so there is no need to move in to PMOD5

In case of PMOD6 and PMOD7 both C and D matrix satisfy positive definiteness condition, although in few cases their ranks are 2.

Table 18: Curvature Conditions			
Model	DET1	DET2	DET3
PMOD4	13.732	31.370	37.505
PMOD5	3.433	1.961	0.586
PMOD6 D	3.723	1.033	0.000
PMOD6 C	3.569	0.984	0.000
PMOD7 D	4.942	4.163	1.214
PMOD7 C	3.365	0.075	0.000

Next we look at the own elasticities of supply in table 19 and 20. Specifically we look at those from PMOD1-5. The labels of the elasticities and their expected signs are given below:

E11 = Domestic Output (+)

E22 = Exports (+)

E33 = Imports (-)

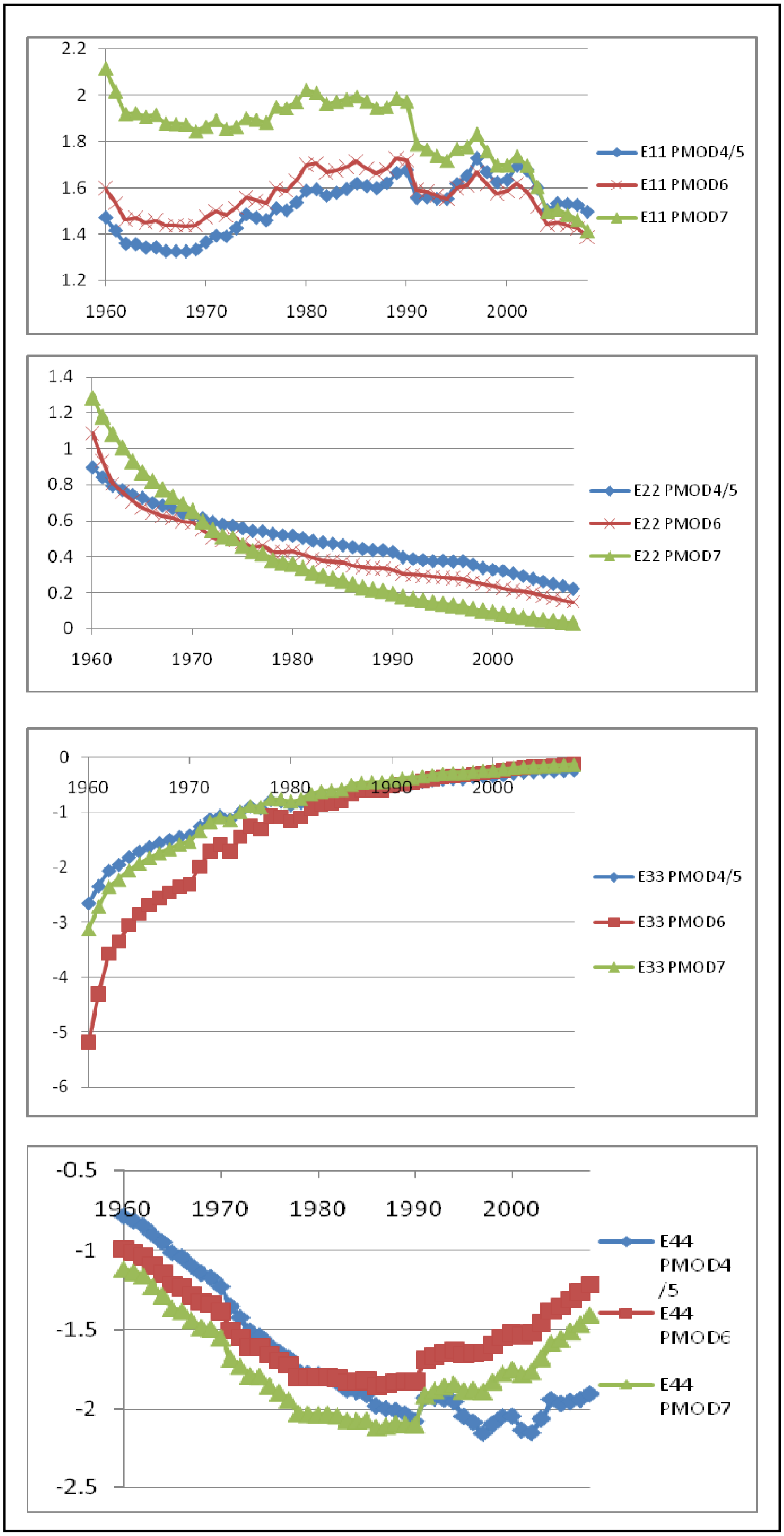
E44 = Labour (-)

Table 19: Price Elasticities of Net Supply								
	PMOD1				PMOD2			
YEAR	E11	E22	E33	E44	E11	E22	E33	E44
1960	1.606	1.177	0.277	-1.060	0.887	0.167	-0.267	-0.066
1961	1.634	1.195	0.316	-1.130	0.842	0.156	-0.148	0.033
1962	1.657	1.222	0.397	-1.195	0.781	0.148	0.009	0.164
1963	1.692	1.172	0.358	-1.304	0.825	0.153	-0.027	0.011
1964	1.705	1.129	0.386	-1.391	0.804	0.156	0.021	-0.021
1965	1.742	1.101	0.374	-1.495	0.848	0.162	-0.003	-0.164
1966	1.742	1.057	0.337	-1.541	0.773	0.160	0.095	-0.056
1967	1.760	1.025	0.305	-1.616	0.763	0.165	0.115	-0.096
1968	1.760	0.988	0.267	-1.679	0.719	0.172	0.156	-0.084
1969	1.802	0.968	0.092	-1.740	0.749	0.175	0.105	-0.136
1970	1.848	0.947	-0.081	-1.828	0.836	0.197	-0.046	-0.343
1971	1.942	0.957	-0.039	-1.963	1.002	0.208	-0.138	-0.653
1972	2.001	0.966	0.004	-2.044	1.040	0.200	-0.091	-0.716
1973	2.098	0.968	-0.125	-2.137	1.179	0.205	-0.206	-0.911
1974	2.082	0.934	-0.417	-2.186	1.239	0.285	-0.499	-1.093
1975	2.105	0.935	-0.293	-2.241	1.223	0.278	-0.448	-1.081
1976	2.123	0.937	-0.189	-2.288	1.196	0.271	-0.398	-1.049
1977	2.136	0.936	-0.430	-2.331	1.259	0.331	-0.608	-1.176
1978	2.197	0.936	-0.220	-2.399	1.280	0.298	-0.520	-1.181
1979	2.236	0.935	-0.470	-2.432	1.349	0.335	-0.694	-1.265
1980	2.250	0.955	-0.754	-2.460	1.409	0.403	-0.899	-1.365
1981	2.307	0.956	-0.840	-2.495	1.456	0.401	-0.956	-1.385
1982	2.334	0.945	-0.736	-2.531	1.410	0.368	-0.874	-1.301
1983	2.360	0.946	-0.740	-2.574	1.483	0.384	-0.898	-1.435
1984	2.346	0.965	-0.818	-2.602	1.519	0.429	-0.957	-1.548
1985	2.372	0.984	-0.946	-2.633	1.616	0.470	-1.053	-1.700
1986	2.387	0.961	-0.743	-2.683	1.616	0.441	-0.932	-1.736
1987	2.389	0.960	-0.687	-2.711	1.619	0.438	-0.883	-1.773
1988	2.413	0.980	-0.831	-2.740	1.713	0.480	-0.986	-1.915
1989	2.403	1.028	-0.997	-2.772	1.796	0.564	-1.125	-2.084
1990	2.464	1.013	-0.991	-2.814	1.892	0.552	-1.130	-2.189
1991	2.455	1.000	-0.974	-2.779	1.772	0.475	-0.969	-2.001
1992	2.498	1.007	-1.056	-2.805	1.832	0.492	-1.049	-2.056
1993	2.481	1.019	-1.034	-2.828	1.793	0.513	-1.050	-2.042
1994	2.471	1.024	-0.990	-2.856	1.764	0.528	-1.043	-2.037
1995	2.475	1.050	-1.006	-2.914	1.831	0.601	-1.150	-2.181
1996	2.511	1.066	-1.085	-2.954	1.911	0.644	-1.252	-2.283
1997	2.529	1.124	-1.235	-3.003	2.029	0.750	-1.434	-2.465
1998	2.519	1.145	-1.261	-3.014	1.994	0.768	-1.448	-2.439
1999	2.535	1.168	-1.338	-3.030	2.012	0.793	-1.502	-2.455
2000	2.532	1.242	-1.478	-3.064	2.082	0.895	-1.648	-2.581
2001	2.576	1.276	-1.542	-3.132	2.152	0.980	-1.763	-2.698
2002	2.617	1.251	-1.497	-3.173	2.111	0.970	-1.743	-2.649
2003	2.590	1.276	-1.512	-3.172	1.961	0.973	-1.708	-2.494
2004	2.576	1.304	-1.577	-3.154	1.808	0.961	-1.680	-2.304
2005	2.599	1.366	-1.692	-3.200	1.843	1.052	-1.801	-2.381
2006	2.593	1.431	-1.781	-3.226	1.801	1.124	-1.873	-2.372
2007	2.571	1.504	-1.854	-3.251	1.739	1.201	-1.934	-2.352
2008	2.587	1.531	-1.910	-3.267	1.678	1.221	-1.957	-2.281
Avg	2.237	1.081	-0.675	-2.446	1.454	0.492	-0.843	-1.436

Table 20: PMOD4 & 5				
YEAR	E11	E22	E33	E44
1960	1.471	0.896	-2.651	-0.788
1961	1.416	0.843	-2.340	-0.818
1962	1.359	0.793	-2.056	-0.848
1963	1.357	0.771	-1.947	-0.903
1964	1.342	0.743	-1.811	-0.952
1965	1.342	0.726	-1.704	-1.018
1966	1.325	0.700	-1.624	-1.046
1967	1.325	0.684	-1.550	-1.100
1968	1.325	0.668	-1.494	-1.147
1969	1.332	0.642	-1.442	-1.174
1970	1.366	0.628	-1.414	-1.232
1971	1.393	0.615	-1.253	-1.355
1972	1.390	0.592	-1.117	-1.425
1973	1.425	0.579	-1.053	-1.513
1974	1.484	0.573	-1.120	-1.542
1975	1.470	0.557	-0.988	-1.598
1976	1.459	0.542	-0.886	-1.643
1977	1.510	0.542	-0.919	-1.677
1978	1.502	0.528	-0.779	-1.767
1979	1.535	0.521	-0.800	-1.781
1980	1.586	0.518	-0.855	-1.786
1981	1.592	0.504	-0.821	-1.805
1982	1.564	0.487	-0.728	-1.834
1983	1.577	0.478	-0.683	-1.880
1984	1.593	0.472	-0.672	-1.893
1985	1.617	0.465	-0.670	-1.910
1986	1.606	0.454	-0.574	-1.981
1987	1.597	0.444	-0.530	-1.999
1988	1.619	0.437	-0.530	-2.010
1989	1.663	0.436	-0.545	-2.034
1990	1.675	0.425	-0.504	-2.079
1991	1.555	0.398	-0.476	-1.930
1992	1.558	0.388	-0.463	-1.932
1993	1.552	0.381	-0.438	-1.937
1994	1.551	0.375	-0.409	-1.955
1995	1.616	0.378	-0.391	-2.047
1996	1.649	0.373	-0.380	-2.085
1997	1.726	0.375	-0.385	-2.155
1998	1.667	0.356	-0.360	-2.097
1999	1.623	0.338	-0.344	-2.048
2000	1.633	0.329	-0.340	-2.046
2001	1.693	0.322	-0.318	-2.134
2002	1.676	0.307	-0.283	-2.151
2003	1.598	0.293	-0.269	-2.063
2004	1.503	0.277	-0.262	-1.940
2005	1.532	0.262	-0.254	-1.967
2006	1.529	0.248	-0.247	-1.954
2007	1.525	0.237	-0.239	-1.942
2008	1.496	0.222	-0.228	-1.906
Avg	1.520	0.492	-0.860	-1.690

Table 21: PMOD6/7								
	PMOD6				PMOD7			
YEAR	E11	E22	E33	E44	E11	E22	E33	E44
1960	1.598	1.087	-5.191	-0.993	2.115	1.283	-3.125	-1.115
1961	1.532	0.934	-4.310	-1.015	2.016	1.181	-2.714	-1.137
1962	1.463	0.805	-3.576	-1.038	1.919	1.082	-2.350	-1.158
1963	1.469	0.760	-3.358	-1.098	1.923	1.007	-2.218	-1.227
1964	1.451	0.708	-3.054	-1.147	1.906	0.932	-2.049	-1.283
1965	1.459	0.673	-2.848	-1.217	1.915	0.869	-1.923	-1.364
1966	1.436	0.647	-2.691	-1.235	1.879	0.823	-1.822	-1.382
1967	1.437	0.628	-2.559	-1.285	1.877	0.776	-1.733	-1.439
1968	1.435	0.616	-2.461	-1.326	1.874	0.735	-1.664	-1.487
1969	1.439	0.595	-2.359	-1.338	1.843	0.694	-1.580	-1.494
1970	1.474	0.589	-2.313	-1.387	1.865	0.655	-1.528	-1.548
1971	1.500	0.548	-1.983	-1.504	1.891	0.597	-1.335	-1.682
1972	1.482	0.507	-1.705	-1.549	1.854	0.548	-1.169	-1.727
1973	1.512	0.491	-1.590	-1.611	1.864	0.514	-1.086	-1.790
1974	1.559	0.515	-1.710	-1.610	1.901	0.501	-1.135	-1.792
1975	1.544	0.478	-1.447	-1.658	1.893	0.463	-0.988	-1.852
1976	1.533	0.451	-1.255	-1.693	1.882	0.430	-0.875	-1.895
1977	1.599	0.460	-1.302	-1.723	1.948	0.418	-0.894	-1.939
1978	1.587	0.426	-1.063	-1.797	1.943	0.382	-0.752	-2.027
1979	1.631	0.425	-1.084	-1.801	1.971	0.368	-0.759	-2.032
1980	1.697	0.432	-1.157	-1.797	2.023	0.359	-0.797	-2.033
1981	1.705	0.416	-1.088	-1.799	2.010	0.338	-0.754	-2.032
1982	1.664	0.392	-0.932	-1.806	1.963	0.312	-0.661	-2.038
1983	1.674	0.381	-0.854	-1.830	1.971	0.293	-0.612	-2.070
1984	1.689	0.376	-0.824	-1.825	1.982	0.281	-0.593	-2.071
1985	1.714	0.369	-0.805	-1.819	1.993	0.267	-0.581	-2.069
1986	1.683	0.354	-0.668	-1.856	1.973	0.246	-0.494	-2.116
1987	1.662	0.344	-0.602	-1.846	1.943	0.231	-0.450	-2.105
1988	1.681	0.337	-0.589	-1.830	1.948	0.219	-0.442	-2.089
1989	1.726	0.335	-0.592	-1.823	1.986	0.211	-0.445	-2.092
1990	1.718	0.324	-0.533	-1.827	1.972	0.196	-0.406	-2.096
1991	1.590	0.308	-0.489	-1.691	1.789	0.179	-0.379	-1.911
1992	1.582	0.299	-0.463	-1.667	1.766	0.167	-0.363	-1.880
1993	1.566	0.294	-0.427	-1.644	1.739	0.157	-0.338	-1.856
1994	1.552	0.289	-0.388	-1.629	1.718	0.147	-0.311	-1.840
1995	1.597	0.286	-0.360	-1.655	1.770	0.139	-0.291	-1.884
1996	1.610	0.280	-0.339	-1.644	1.777	0.130	-0.278	-1.875
1997	1.666	0.275	-0.332	-1.643	1.831	0.124	-0.275	-1.888
1998	1.615	0.262	-0.301	-1.595	1.757	0.111	-0.252	-1.827
1999	1.574	0.248	-0.277	-1.550	1.697	0.100	-0.236	-1.771
2000	1.586	0.237	-0.264	-1.524	1.697	0.091	-0.227	-1.749
2001	1.620	0.226	-0.236	-1.537	1.738	0.084	-0.206	-1.780
2002	1.581	0.215	-0.202	-1.520	1.696	0.074	-0.180	-1.760
2003	1.517	0.206	-0.184	-1.458	1.605	0.066	-0.168	-1.679
2004	1.441	0.198	-0.173	-1.383	1.499	0.057	-0.161	-1.580
2005	1.450	0.182	-0.159	-1.354	1.507	0.050	-0.152	-1.557
2006	1.437	0.170	-0.147	-1.309	1.485	0.043	-0.143	-1.510
2007	1.424	0.159	-0.135	-1.264	1.462	0.037	-0.135	-1.463
2008	1.386	0.148	-0.123	-1.216	1.415	0.031	-0.126	-1.407
Avg	1.562	0.422	-1.255	-1.538	1.836	0.388	-0.860	-1.743

Figure 9: Trend in Elasticities



Results from Table 19-21 are used to develop the graphs displayed in figure 9. From these it is evident that the elasticities of these entire models follow a very similar path. Only in case of E11, domestic output, PMOD7 estimates are divergent from estimates from other PMOD models. But if we recall, the goodness of fit or R^2 value on domestic output regression, displayed in table 16, for PMOD 7 it is very low at around 70%. That might explain the divergence in E11 graph.

All the elasticities in these models have the expected signs. Although the estimates suggest that other than export, all the rest are highly elastic. This is interesting but not impossible. For instance such elasticities are obtained when one runs the program for South Korea or even Italy. As a matter of fact for Italy the trend also matches those of Switzerland. However such high elasticities are rare. Based on the elasticities, goodness of fit and closeness to previous measure of Technical progress, the author believes PMOD 4 is the best model. Although PMOD6 has a close technical progress measure but elasticities for export, E33 in the 60s reach over 5, which seems to be highly unlikely.

8. Consumer Models : Theoretical framework

In this section we look at the consumer side of the economy. The models are developed based on the methodology developed by Diewert and Wales (1993) and Diewert and Fox (2009)[12]. Similar to previous models, these models are flexible, i.e. they can approximate arbitrary twice continuously differentiable functions to the second order at an arbitrary point of approximation. Flexible functional form ensures that elasticities of supply and demand are not arbitrarily restricted by the choice of the functional form. The reason for choosing normalized quadratic form rest on the fact that, as Diewert explains, in no other models can we impose convexity or concavity restrictions in a parsimonious way without destroying the flexibility of the functional form. Here we provide a brief overview of the Normalized quadratic form employed in the consumer modelling. This is taken from Diewert and Wales (1993) and hence for further detail one should review the aforesaid references.

Given a utility level u, a vector of positive consumer prices $p = (p_1..... ,P_N) >> O_N$ and a preference function f, the consumer's expenditure function E is defined by $E(u, p) = \min_x \{p. x: f(x) \geq u\}$, where $p.x = p^T x = \sum p_i x_i$ is the inner product between x and p. Diewert and Wales define the normalized quadratic expenditure function for $u > 0$ and $p > O_N$ as :

$$E(u, p) = a.p + [b.p - (1/2)(\alpha.p)^{-1} p^T A A^T p]u$$

where $\alpha = (\alpha_1, \ldots, \alpha_N)$ is a predetermined vector of parameters that satisfies the following restrictions:

$$\alpha.p^* = 1, \quad \alpha \geq O_N,$$

where $p^* = (p_1^*,....,p_N^*)^T >> O_N$ is a reference (or base period) price vector. The unknown vectors $a = (a_1, ...,a_N)^T$ and $b = (b_1,\ldots, b_N)^T$ and the lower triangular matrix $A = [a_{ij}]$ with $a_{ij} = 0$ for $1 \leq i < j \leq N$. Thus there are $N + N + N(N + 1)/2$ free parameters, however, we assume that these parameters satisfy the following $2 + N$ linear restrictions (so that E has only $N(N + 3)/2 - 2$ free parameters):

$$a.p^* = 0$$

$$b.p^* = 1$$

$$A^T.p^* = O_N$$

[12]The normalized quadratic expenditure function, Discussion Paper 09-04, Department of Economics, UBC, http://faculty.arts.ubc.ca/ediewert/dp0904.pdf

Once these restrictions are imposed the normalized quadratic expenditure function has the following money metric utility scaling property (at the reference prices p*): E(u,p*)= u for u ≥ O. Which implies that the consumer's utility is measured by the size of the budget set provided that prices remained fixed at p*. Diewert etal then show a mechanism to obtain the consumer's system of Hicksian demand functions X(u,p), by differentiating the expenditure function with respect to prices;

$$\bar{x}(u, p) = \nabla_p E(u, p) = a + [b - (\alpha.p)^{-1} AA^T p + (1/2)(\alpha.p)^{-2} p^T AA^T p\ \alpha]u$$

where $\nabla_p E(u, p)$ is the column vector of the derivatives of E with respect to the components of p. In the following tables we adapt this framework for empirical exercise with Swiss economy being the case point. First we develop some of the required quantity and price index series. Our two commodities are labour and consumption, so we develop quantity and price series for these parameters. Our previous estimate PL for price of labour was accurate for employees and hence we have to take out the taxes TRL from the series to arrive at the accurate price of labour. However in case of consumption they already include the commodity taxes and hence do not need to be adjusted. Also the series provided in table 22 are in per capita format.

9. Consumer Models : Empirical Analysis

Table 22: Utility Index and Expenditure				
YEAR	X1	X2	PC1	PC2
1960	7.110	5.209	1.000	1.000
1961	7.442	5.401	1.030	1.067
1962	7.735	5.465	1.081	1.150
1963	7.926	5.405	1.118	1.266
1964	8.188	5.399	1.166	1.383
1965	8.394	5.309	1.213	1.508
1966	8.583	5.255	1.270	1.585
1967	8.750	5.219	1.324	1.710
1968	8.970	5.181	1.358	1.794
1969	9.360	5.200	1.399	1.862
1970	9.813	5.240	1.453	2.057
1971	10.253	5.294	1.554	2.443
1972	10.724	5.261	1.672	2.766
1973	10.926	5.200	1.823	3.038
1974	10.795	5.084	2.005	3.375
1975	10.469	4.804	2.138	3.574
1976	10.615	4.677	2.186	3.609
1977	10.937	4.622	2.211	3.719
1978	11.125	4.611	2.225	3.916
1979	11.180	4.601	2.322	4.129
1980	11.349	4.620	2.427	4.398
1981	11.328	4.619	2.563	4.716
1982	11.226	4.556	2.711	5.070
1983	11.246	4.480	2.796	5.321
1984	11.303	4.435	2.880	5.463
1985	11.415	4.475	2.975	5.796
1986	11.606	4.521	3.015	6.023
1987	11.778	4.594	3.060	6.262
1988	11.897	4.682	3.120	6.463
1989	12.088	4.722	3.212	6.895
1990	12.138	4.811	3.378	7.333
1991	12.193	5.086	3.566	7.369
1992	12.133	5.026	3.708	7.596
1993	11.993	4.945	3.809	7.739
1994	12.053	4.880	3.820	7.734
1995	12.071	4.802	3.874	8.064
1996	12.166	4.729	3.923	8.190
1997	12.328	4.655	3.955	8.566
1998	12.571	4.753	3.953	8.451
1999	12.807	4.824	3.967	8.577
2000	13.046	4.820	3.999	8.674
2001	13.222	4.749	4.026	9.481
2002	13.105	4.684	4.060	9.616
2003	13.097	4.673	4.075	9.571
2004	13.188	4.728	4.109	9.329
2005	13.331	4.704	4.129	9.626
2006	13.445	4.724	4.184	9.863
2007	13.635	4.772	4.240	10.275
2008	13.669	4.847	4.334	10.450

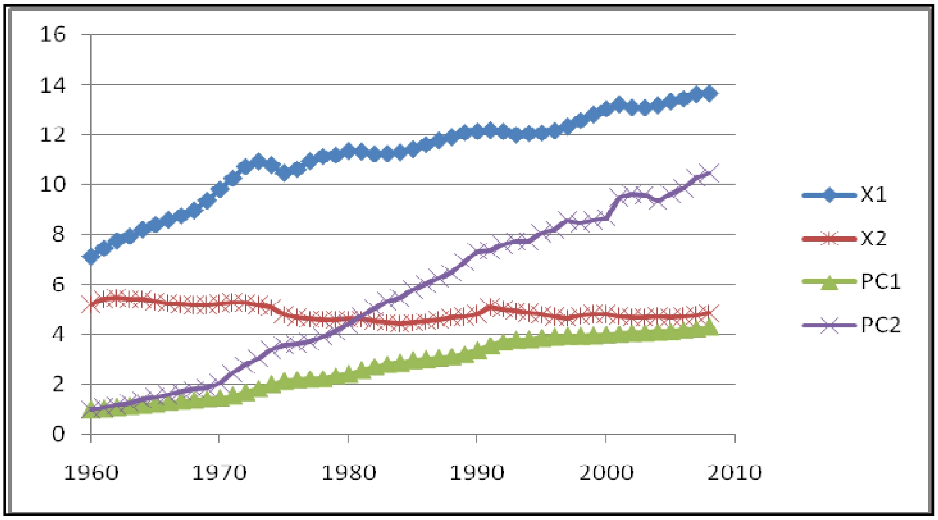
X1 = per pop consumption;

X2 = per pop labour supply

PC1 = Price of Consumption

PC2= Wage rate for all types of worker (adjusted for tax, TRL)

Figure 10: Price Quantity index movement of Labour and Consumption



From the above graph we can see how the standard of living for the Swiss has increased. Labour supply has remained more or less stable or has a very low declining trend. On the other hand price of labour, even after adjusting for tax, has increased at a much faster rate than the price of consumption. We also see that the quantity of consumption has also gone up significantly.

In the next table we convert labour supply into leisure demand assuming effective hours is twice the average hours of labour supplied. As Diewert says this is the inherent weakness of a leisure model; the maximum number of hours that could be worked is somewhat arbitrary. Also given that Swiss have one of the highest annual working hours in Europe, a factor of 2 as suggested by Diewert might be too large. However if one were to assume the factor was around 1.5, results hardly vary characteristically and so we stick with Diewert's suggestion.

Table 23: Welfare Indices and Output				
YEAR	INDEXU	Y	W	PL
1960	11.670	11.670	1.000	1.000
1961	11.806	12.330	1.063	1.068
1962	12.027	13.313	1.140	1.152
1963	12.276	14.391	1.221	1.269
1964	12.530	15.587	1.316	1.386
1965	12.823	16.905	1.412	1.512
1966	13.058	18.059	1.515	1.611
1967	13.251	19.365	1.614	1.738
1968	13.496	20.414	1.691	1.841
1969	13.822	21.600	1.794	1.948
1970	14.174	23.573	1.963	2.157
1971	14.482	26.861	2.210	2.536
1972	14.917	30.401	2.452	2.876
1973	15.165	33.798	2.746	3.287
1974	15.217	37.462	3.081	3.709
1975	15.334	40.129	3.313	4.016
1976	15.626	41.582	3.382	4.161
1977	15.965	43.330	3.463	4.308
1978	16.131	44.949	3.574	4.515
1979	16.189	47.303	3.691	4.726
1980	16.296	50.189	3.890	5.014
1981	16.281	53.317	4.132	5.371
1982	16.293	56.865	4.423	5.775
1983	16.418	59.589	4.588	6.074
1984	16.529	61.691	4.717	6.333
1985	16.555	64.647	4.864	6.623
1986	16.632	66.604	5.037	6.932
1987	16.649	68.445	5.158	7.124
1988	16.604	69.997	5.338	7.384
1989	16.682	73.628	5.540	7.809
1990	16.580	77.371	5.864	8.300
1991	16.192	77.993	6.272	8.307
1992	16.240	81.019	6.574	8.612
1993	16.259	83.023	6.750	8.864
1994	16.402	83.866	6.846	8.988
1995	16.533	86.819	6.938	9.318
1996	16.717	89.013	7.022	9.537
1997	16.949	92.570	7.055	9.843
1998	16.973	92.085	7.103	9.811
1999	17.033	93.223	7.125	9.815
2000	17.213	95.109	7.217	10.140
2001	17.452	100.828	7.393	10.775
2002	17.477	102.103	7.526	11.069
2003	17.490	102.149	7.632	10.965
2004	17.464	101.229	7.702	10.723
2005	17.605	103.810	7.776	11.102
2006	17.650	106.012	7.868	11.426
2007	17.703	109.155	7.996	11.829
2008	17.601	110.676	8.158	12.117

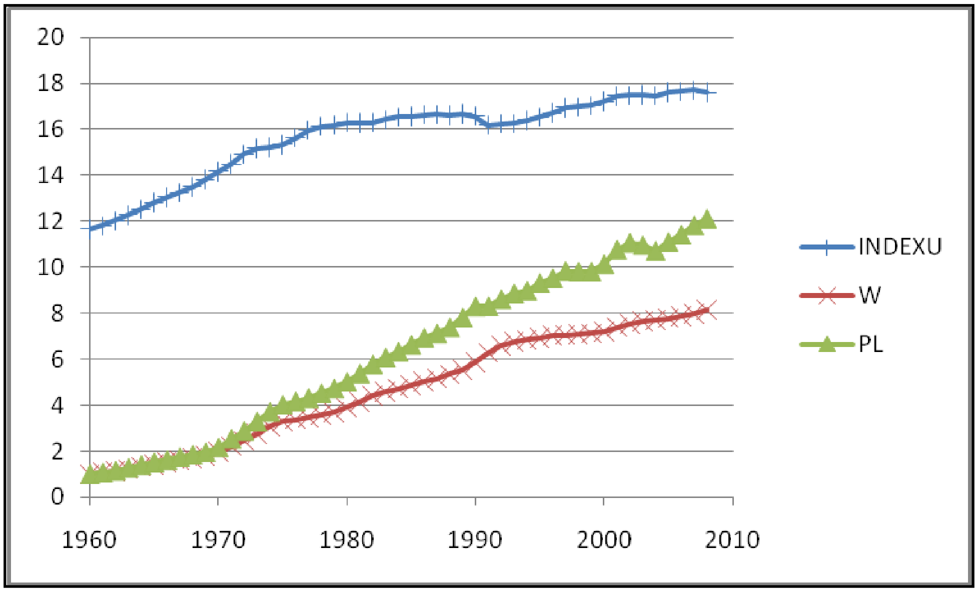
Y = Per Capita Expenditures

INDEXU = Per Capita Utility

W = Wage data based on SUVA

PL= Wage for all type of worker

Figure 11: Trend in Welfare indices



One can note that per capita utility has grown 1.51 fold in Switzerland; more slowly than per capita consumption, which grew 1.923 for the same period. This is explained by the fact that per capita leisure only increased from 4.5601 to 4.9223 over the sample period, although it did increase to 5.3345 at one point (not shown here). Next we run the consumer models developed by Diewert etal. Brief descriptions of the structure of these models are also given.

Table 24: Index Value and Fitted Values				
YEAR	INDEXU	CMOD1,2	CMOD3	CMOD4
1960	11.670	11.670	11.670	11.670
1961	11.806	11.813	11.814	11.814
1962	12.027	12.034	12.035	12.036
1963	12.276	12.280	12.281	12.283
1964	12.530	12.530	12.531	12.532
1965	12.823	12.815	12.817	12.816
1966	13.058	13.044	13.046	13.044
1967	13.251	13.230	13.233	13.229
1968	13.496	13.465	13.469	13.463
1969	13.822	13.778	13.782	13.773
1970	14.174	14.100	14.105	14.091
1971	14.482	14.362	14.367	14.348
1972	14.917	14.754	14.759	14.733
1973	15.165	14.983	14.989	14.959
1974	15.217	15.029	15.035	15.004
1975	15.334	15.138	15.144	15.111
1976	15.626	15.410	15.417	15.380
1977	15.965	15.726	15.734	15.691
1978	16.131	15.881	15.889	15.842
1979	16.189	15.936	15.944	15.894
1980	16.296	16.035	16.043	15.991
1981	16.281	16.022	16.030	15.977
1982	16.293	16.036	16.035	15.907
1983	16.418	16.155	16.159	16.055
1984	16.529	16.256	16.264	16.183
1985	16.555	16.288	16.297	16.220
1986	16.632	16.365	16.377	16.317
1987	16.649	16.387	16.399	16.344
1988	16.604	16.347	16.358	16.291
1989	16.682	16.425	16.439	16.391
1990	16.580	16.333	16.342	16.383
1991	16.192	15.982	15.976	16.038
1992	16.240	16.028	16.024	16.082
1993	16.259	16.046	16.043	16.099
1994	16.402	16.178	16.181	16.227
1995	16.533	16.297	16.305	16.345
1996	16.717	16.464	16.480	16.508
1997	16.949	16.679	16.705	16.719
1998	16.973	16.700	16.727	16.738
1999	17.033	16.754	16.784	16.791
2000	17.213	16.916	16.954	16.949
2001	17.452	17.123	17.174	17.153
2002	17.477	17.146	17.198	17.175
2003	17.490	17.157	17.210	17.186
2004	17.464	17.134	17.184	17.162
2005	17.605	17.259	17.316	17.284
2006	17.650	17.299	17.359	17.324
2007	17.703	17.344	17.408	17.368
2008	17.601	17.254	17.312	17.280

CMOD1 -Two good consumer regression model based on the normalized quadratic expenditure function; curvature conditions are not imposed.

CMOD2- Two good consumer regression model based on the normalized quadratic expenditure function; curvature conditions are imposed.

CMOD3 -Two good consumer regression model based on the normalized quadratic expenditure function; curvature conditions are imposed; linear splines are used to model utility. Break Points: 1981.

CMOD4- Two good consumer regression model based on the normalized quadratic expenditure function; curvature conditions are imposed; linear splines are used to model utility. Break Points: 1981 and 1989.

Table 25: CMOD Summary							
Average	EC11	EC12	EC21	EC22	ECU1	ECU2	ECEU
CMOD1 &2	-0.328	0.328	0.411	-0.411	0.846	1.342	1.064
CMOD3	-0.319	0.319	0.400	-0.400	0.893	1.228	1.037
CMOD4	-0.329	0.329	0.412	-0.412	0.885	1.252	1.041

The aforesaid table 25 provides the summary statistics of the consumer models. It is interesting to note that all the elasticities have the right sign; considering in most cases they don't come out right this is indeed great news. Also note that both consumption and leisure is a normal good (ecu1 and ecu2 are positive). However we see that for leisure the elasticity is greater than 1 and for consumption it is less than 1, which is a suspect but it is not unheard of.

Table 26: CMOD 1 and 2							
YEAR	**EC11**	**EC12**	**EC21**	**EC22**	**ECU1**	**ECU2**	**ECEU**
1960	-0.223	0.223	0.390	-0.390	0.775	1.393	1.000
1961	-0.231	0.231	0.395	-0.395	0.779	1.391	1.005
1962	-0.237	0.237	0.397	-0.397	0.784	1.386	1.009
1963	-0.250	0.250	0.404	-0.404	0.790	1.384	1.017
1964	-0.259	0.259	0.408	-0.408	0.796	1.381	1.023
1965	-0.269	0.269	0.412	-0.412	0.802	1.376	1.029
1966	-0.271	0.271	0.410	-0.410	0.805	1.368	1.029
1967	-0.278	0.278	0.412	-0.412	0.809	1.366	1.033
1968	-0.283	0.283	0.413	-0.413	0.813	1.361	1.036
1969	-0.285	0.285	0.410	-0.410	0.817	1.351	1.036
1970	-0.297	0.297	0.414	-0.414	0.824	1.349	1.043
1971	-0.314	0.314	0.422	-0.422	0.832	1.355	1.055
1972	-0.323	0.323	0.422	-0.422	0.838	1.350	1.060
1973	-0.324	0.324	0.420	-0.420	0.841	1.344	1.060
1974	-0.326	0.326	0.420	-0.420	0.841	1.344	1.061
1975	-0.325	0.325	0.419	-0.419	0.842	1.340	1.060
1976	-0.325	0.325	0.415	-0.415	0.844	1.330	1.057
1977	-0.328	0.328	0.414	-0.414	0.847	1.324	1.058
1978	-0.334	0.334	0.415	-0.415	0.851	1.326	1.063
1979	-0.336	0.336	0.415	-0.415	0.852	1.326	1.064
1980	-0.338	0.338	0.415	-0.415	0.854	1.325	1.065
1981	-0.340	0.340	0.415	-0.415	0.854	1.328	1.067
1982	-0.342	0.342	0.416	-0.416	0.855	1.330	1.069
1983	-0.344	0.344	0.415	-0.415	0.857	1.329	1.071
1984	-0.344	0.344	0.414	-0.414	0.858	1.326	1.070
1985	-0.346	0.346	0.414	-0.414	0.859	1.328	1.073
1986	-0.349	0.349	0.414	-0.414	0.861	1.330	1.075
1987	-0.351	0.351	0.414	-0.414	0.862	1.332	1.078
1988	-0.352	0.352	0.414	-0.414	0.862	1.335	1.080
1989	-0.355	0.355	0.413	-0.413	0.865	1.338	1.083
1990	-0.355	0.355	0.414	-0.414	0.865	1.342	1.085
1991	-0.351	0.351	0.417	-0.417	0.860	1.345	1.081
1992	-0.350	0.350	0.417	-0.417	0.860	1.343	1.080
1993	-0.349	0.349	0.417	-0.417	0.859	1.341	1.079
1994	-0.350	0.350	0.416	-0.416	0.860	1.337	1.078
1995	-0.352	0.352	0.415	-0.415	0.862	1.337	1.081
1996	-0.353	0.353	0.413	-0.413	0.864	1.333	1.080
1997	-0.356	0.356	0.411	-0.411	0.867	1.332	1.083
1998	-0.355	0.355	0.411	-0.411	0.867	1.330	1.081
1999	-0.356	0.356	0.410	-0.410	0.867	1.330	1.082
2000	-0.357	0.357	0.409	-0.409	0.869	1.326	1.082
2001	-0.362	0.362	0.404	-0.404	0.874	1.332	1.090
2002	-0.362	0.362	0.404	-0.404	0.874	1.332	1.091
2003	-0.362	0.362	0.404	-0.404	0.874	1.331	1.090
2004	-0.360	0.360	0.406	-0.406	0.872	1.327	1.086
2005	-0.362	0.362	0.404	-0.404	0.874	1.327	1.088
2006	-0.362	0.362	0.403	-0.403	0.875	1.328	1.089
2007	-0.363	0.363	0.401	-0.401	0.877	1.330	1.092
2008	-0.363	0.363	0.402	-0.402	0.876	1.332	1.092
Avg	-0.328	0.328	0.411	-0.411	0.846	1.342	1.064

EC11, EC12,EC21 and EC22 Hicksian Price Elasticities of Demand

ECU1 and ECU2 Hicksian Elasticities of Demand w.r.t. Real Income

ECEU Elasticity of Expenditure w.r.t. Utility

Table 26-28 provides the entire data from CMOD1-4, the summary of which was provided in Table 25. Since the restrictions in CMOD 1 were satisfied, imposing curvature condition did not affect the results and as such finding from CMOD1 and CMOD2 were identical. It is interesting to note that the trends in elasticities for all the CMODs are fairly close to each other. But as mentioned before the elasticity of leisure does seem to be bit high, although within acceptable limit. In the final section of the paper we undertake benchmarking exercise.

Table 27: CMOD 3							
YEAR	EC11	EC12	EC21	EC22	ECU1	ECU2	ECEU
1960	-0.217	0.217	0.380	-0.380	0.784	1.378	1
1961	-0.224	0.224	0.384	-0.384	0.788	1.377	1.005
1962	-0.230	0.230	0.386	-0.386	0.792	1.371	1.008
1963	-0.242	0.242	0.393	-0.393	0.799	1.37	1.017
1964	-0.252	0.252	0.397	-0.397	0.804	1.367	1.022
1965	-0.261	0.261	0.400	-0.400	0.81	1.362	1.028
1966	-0.263	0.263	0.398	-0.398	0.813	1.354	1.028
1967	-0.270	0.270	0.401	-0.401	0.817	1.352	1.032
1968	-0.274	0.274	0.401	-0.401	0.82	1.347	1.034
1969	-0.277	0.277	0.399	-0.399	0.824	1.338	1.034
1970	-0.288	0.288	0.403	-0.403	0.83	1.336	1.041
1971	-0.305	0.305	0.410	-0.410	0.838	1.342	1.053
1972	-0.314	0.314	0.409	-0.409	0.844	1.336	1.058
1973	-0.315	0.315	0.408	-0.408	0.847	1.33	1.058
1974	-0.317	0.317	0.408	-0.408	0.847	1.33	1.059
1975	-0.316	0.316	0.406	-0.406	0.848	1.326	1.057
1976	-0.316	0.316	0.403	-0.403	0.85	1.317	1.055
1977	-0.319	0.319	0.402	-0.402	0.853	1.311	1.056
1978	-0.325	0.325	0.403	-0.403	0.857	1.313	1.06
1979	-0.326	0.326	0.403	-0.403	0.857	1.313	1.061
1980	-0.329	0.329	0.402	-0.402	0.859	1.313	1.063
1981	-0.331	0.331	0.403	-0.403	0.86	1.315	1.065
1982	-0.333	0.333	0.402	-0.402	0.941	1.134	1.028
1983	-0.335	0.335	0.402	-0.402	0.942	1.134	1.029
1984	-0.335	0.335	0.402	-0.402	0.942	1.133	1.028
1985	-0.337	0.337	0.402	-0.402	0.942	1.134	1.03
1986	-0.340	0.340	0.402	-0.402	0.943	1.134	1.031
1987	-0.342	0.342	0.402	-0.402	0.944	1.135	1.032
1988	-0.343	0.343	0.402	-0.402	0.944	1.136	1.032
1989	-0.345	0.345	0.401	-0.401	0.945	1.138	1.034
1990	-0.346	0.346	0.401	-0.401	0.945	1.139	1.035
1991	-0.342	0.342	0.403	-0.403	0.943	1.14	1.033
1992	-0.341	0.341	0.403	-0.403	0.943	1.139	1.033
1993	-0.341	0.341	0.403	-0.403	0.942	1.138	1.032
1994	-0.341	0.341	0.402	-0.402	0.943	1.137	1.032
1995	-0.343	0.343	0.402	-0.402	0.944	1.137	1.033
1996	-0.343	0.343	0.401	-0.401	0.944	1.136	1.033
1997	-0.346	0.346	0.400	-0.400	0.946	1.136	1.034
1998	-0.345	0.345	0.400	-0.400	0.946	1.135	1.033
1999	-0.346	0.346	0.400	-0.400	0.946	1.135	1.034
2000	-0.347	0.347	0.399	-0.399	0.947	1.133	1.033
2001	-0.351	0.351	0.395	-0.395	0.949	1.136	1.037
2002	-0.352	0.352	0.395	-0.395	0.949	1.136	1.037
2003	-0.351	0.351	0.395	-0.395	0.949	1.135	1.037
2004	-0.350	0.350	0.397	-0.397	0.948	1.134	1.035
2005	-0.351	0.351	0.395	-0.395	0.949	1.134	1.036
2006	-0.352	0.352	0.395	-0.395	0.949	1.134	1.036
2007	-0.353	0.353	0.393	-0.393	0.95	1.135	1.038
2008	-0.353	0.353	0.394	-0.394	0.95	1.136	1.038
Avg	-0.319	0.319	0.400	-0.400	0.893	1.228	1.037

Table 28: CMOD4							
YEAR	EC11	EC12	EC21	EC22	ECU1	ECU2	ECEU
1960	-0.223	0.223	0.394	-0.394	0.731	1.476	1.000
1961	-0.230	0.230	0.399	-0.399	0.735	1.474	1.006
1962	-0.237	0.237	0.400	-0.400	0.741	1.466	1.010
1963	-0.250	0.250	0.407	-0.407	0.748	1.464	1.021
1964	-0.260	0.260	0.411	-0.411	0.755	1.460	1.028
1965	-0.270	0.270	0.414	-0.414	0.762	1.453	1.035
1966	-0.272	0.272	0.411	-0.411	0.766	1.443	1.035
1967	-0.279	0.279	0.413	-0.413	0.770	1.440	1.040
1968	-0.284	0.284	0.413	-0.413	0.775	1.433	1.043
1969	-0.287	0.287	0.410	-0.410	0.779	1.421	1.043
1970	-0.298	0.298	0.414	-0.414	0.787	1.418	1.051
1971	-0.316	0.316	0.420	-0.420	0.797	1.425	1.066
1972	-0.325	0.325	0.420	-0.420	0.804	1.418	1.072
1973	-0.327	0.327	0.417	-0.417	0.807	1.411	1.072
1974	-0.328	0.328	0.418	-0.418	0.808	1.411	1.073
1975	-0.328	0.328	0.416	-0.416	0.809	1.405	1.072
1976	-0.327	0.327	0.412	-0.412	0.811	1.393	1.069
1977	-0.331	0.331	0.410	-0.410	0.815	1.386	1.070
1978	-0.337	0.337	0.411	-0.411	0.819	1.388	1.076
1979	-0.339	0.339	0.411	-0.411	0.820	1.388	1.077
1980	-0.341	0.341	0.410	-0.410	0.822	1.387	1.079
1981	-0.343	0.343	0.411	-0.411	0.823	1.390	1.081
1982	-0.348	0.348	0.402	-0.402	1.344	0.259	0.840
1983	-0.349	0.349	0.405	-0.405	1.338	0.255	0.836
1984	-0.348	0.348	0.407	-0.407	1.334	0.258	0.838
1985	-0.350	0.350	0.408	-0.408	1.330	0.250	0.831
1986	-0.352	0.352	0.410	-0.410	1.325	0.243	0.826
1987	-0.354	0.354	0.411	-0.411	1.321	0.236	0.819
1988	-0.355	0.355	0.410	-0.410	1.321	0.232	0.815
1989	-0.357	0.357	0.411	-0.411	1.315	0.222	0.807
1990	-0.354	0.354	0.420	-0.420	0.810	1.490	1.121
1991	-0.349	0.349	0.425	-0.425	0.803	1.495	1.115
1992	-0.349	0.349	0.425	-0.425	0.803	1.491	1.113
1993	-0.348	0.348	0.424	-0.424	0.803	1.489	1.112
1994	-0.349	0.349	0.423	-0.423	0.804	1.482	1.110
1995	-0.351	0.351	0.421	-0.421	0.807	1.483	1.114
1996	-0.352	0.352	0.419	-0.419	0.808	1.476	1.113
1997	-0.356	0.356	0.416	-0.416	0.813	1.475	1.118
1998	-0.355	0.355	0.416	-0.416	0.812	1.471	1.115
1999	-0.356	0.356	0.415	-0.415	0.813	1.471	1.117
2000	-0.357	0.357	0.414	-0.414	0.815	1.466	1.116
2001	-0.362	0.362	0.408	-0.408	0.822	1.473	1.128
2002	-0.362	0.362	0.408	-0.408	0.823	1.473	1.129
2003	-0.362	0.362	0.408	-0.408	0.822	1.471	1.127
2004	-0.360	0.360	0.410	-0.410	0.820	1.466	1.122
2005	-0.362	0.362	0.407	-0.407	0.822	1.466	1.125
2006	-0.362	0.362	0.407	-0.407	0.824	1.467	1.127
2007	-0.364	0.364	0.405	-0.405	0.826	1.470	1.131
2008	-0.363	0.363	0.406	-0.406	0.825	1.473	1.131
Avg	-0.329	0.329	0.412	-0.412	0.885	1.252	1.041

10. Benchmarking

In this section we look at the measurement of the efficiency of production under the framework called nonparameteric approach to production theory. The methodology adapted in this section is taken from Diewert (2009)[13]. Here, like before, a brief introduction to the benchmarking methodology is provided. For more detail analysis of the methodology involved please review the aforesaid reference.

First let us assume that we have quantity data on K production units that are producing 2 outputs using 2 inputs. Let $y_m^k \geq 0$ denote the amount of output m produced by each production unit (or firm or plant) k for m = 1, 2, and let $x_m^k \geq 0$ denote the amount of input n used by firm k for n = 1, 2 and k = 1, 2, . . ., K. Furthermore we assume that each firm has access to the same basic technology except for efficiency differences. An approximation to the basic technology is defined to be the convex free disposal hull of the observed quantity data {($y_1^k y_2^k$ $x_1^k x_2^k$: k = 1, ..., K}. As Diewert points out that this technology assumption is consistent with decreasing returns to scale (and constant returns to scale) but it is not consistent with increasing returns to scale.

Then they define inefficiency of observation i by the smallest positive fraction δ_i^* of the ith input vector ($x_1^i x_2^i$) which is such that (y_1^i, y_2^i , δ_i^* x_1^i, δ_i^* x_2^i) is on the efficient frontier spanned by the convex free disposal hull of the K observations. If the i[th] observation is efficient relative to this frontier, then δ_i^* = 1; the smaller δ_i^* is, then the lower is the efficiency of the i[th] observation. The number δ_i^* that can be determined as the optimal objective function of the following linear programming problem:

$$\delta_i^* = \min_{\delta i \geq 0, \lambda 1 \geq 0, \ldots, \lambda K \geq 0} \{\delta_i : \Sigma_{k=1}^K y_1^k \lambda_k \geq y_1^i ;$$
$$\Sigma_{k=1}^K y_2^k \lambda_k \geq y_2^i ;$$
$$\Sigma_{k=1}^K x_1^k \lambda_k \leq \delta_i x_1^i ;$$
$$\Sigma_{k=1}^K x_2^k \lambda_k \leq \delta_i x_2^i ;$$
$$\Sigma_{k=1}^K \lambda_k = 1\}.$$

We look for a convex combination of the K data points that can produce at least the observation i combination of outputs (y_1^i, y_2^i) and use only δ_i times the observation i combination of inputs

[13] Chapter 11: Benchmarking and the Nonparametric Approach to Production Theory, http://faculty.arts.ubc.ca/ediewert/594chmpg.htm

($x_1^i x_2^i$), the smallest such δ_i is δ_i^*. When the underlying technology is subject to constant returns to scale (in addition to being convex), $\sum_{k=1}^{K} \lambda_k = 1$ constraint is dropped from the aforementioned equation.

Next we make the same assumptions on the underlying technology , i.e. convex technology, however, we now assume that each producer may be either minimizing cost or maximizing profits. Now we assume that producer k faces the input prices (w_1^k, w_2^k) for the two inputs. In order to determine whether producer i is minimizing cost subject to the convex technology assumptions, we solve the following linear program:

$$\min_{\lambda_1 \geq 0, \ldots, \lambda_K \geq 0} \{w_1^i(\Sigma_{k=1}^{K} x_1^k \lambda_k) + w_2^i(\Sigma_{k=1}^{K} x_2^k \lambda_k) : \Sigma_{k=1}^{K} y_1^k \lambda_k \geq y_1^i; \; \Sigma_{k=1}^{K} y_2^k \lambda_k \geq y_2^i; \; \Sigma_{k=1}^{K} \lambda_k = 1\}$$

we define the overall efficiency measure ε_i for observation i by equating the optimized objective function above to : $\varepsilon_i^*[w_1^i x_1^i + w_2^i x_2^i]$. As Diewert explains that the number ε_i^* can be interpreted as the fraction of ($x_1^i x_2^i$), which is such that ε_i^*($x_1^i x_2^i$), on the minimum cost isocost line for observation i . It is worth noting that λ_k can also be a solution to the optimization problem mentioned above and as such we can say $0 < \varepsilon_i^* \leq \delta_i^*$, which translates to the fact that overall efficiency ε_i^* is equal to or less than technical efficiency δ_i^*.

Now we look at the case of profit maximization with convex technology. We assume firm i faces the positive output prices ($p_1^i p_2^i$) for the two outputs. Then we solve the following linear programming problem: $\max_{\lambda_1 \geq 0, \ldots, \lambda_K \geq 0} \{\Sigma_{m=1}^{2} p_m^i(\Sigma_{k=1}^{K} y_m^k \lambda_k) - \Sigma_{n=1}^{2} w_n^i(\Sigma_{k=1}^{K} x_n^k \lambda_k) : \Sigma_{k=1}^{K} \lambda_k = 1\}$ and equate it to $p_1^i y_1^i + p_2^i y_2^i - \alpha_i^*[w_1^i x_1^i + w_2^i x_2^i]$.

Diewert then showed that the $\alpha_i^* \leq \varepsilon_i^*$, that is relative efficiency level under the profit maximizing assumption will be equal to or less than the relative efficiency level under the cost minimizing assumption. He also explains that making stronger assumptions on the underlying technology tends to decrease the efficiency measure; while assuming cost minimizing behaviour tends to decrease the efficiency of observation compared to the measure of technical efficiency that was obtained earlier.

Finally we look at the case of conditional profit maximization problem, where we assume of the input is fixed in the short run. Thus assuming input 2 is fixed we solve the following linear programming problem.

$$\begin{aligned} \max_{\lambda_1 \geq 0 \lambda_2 \geq 0, \ldots, \lambda_K \geq 0} & \{\Sigma_{m=1}{}^{2} p_m{}^{i}(\Sigma_{k=1}{}^{K} y_m{}^{k}\lambda_k) - \Sigma_{n=1}{}^{2} w_n{}^{i}(\Sigma_{k=1}{}^{K} x_n{}^{k}\lambda_k) : \Sigma_{k=1}{}^{K} x_2{}^{k}\lambda_k \leq x_2{}^{i}\} \\ & = \max_k \{[\Sigma_{m=1}{}^{2} p_m{}^{i} y_m{}^{k} - (\Sigma_{n=1}{}^{2} w_n{}^{i} x_n{}^{k})][x_2{}^{i}/x_2{}^{k}] : k = 1,2,\ldots,K\}^{19} \\ & \equiv p_1{}^{i} y_1{}^{i} + p_2{}^{i} y_2{}^{i} - \alpha_i{}^{**}[w_1{}^{i} x_1{}^{i} + w_2{}^{i} x_2{}^{i}] \end{aligned}$$

Diewert then shows that the optimal solution $\alpha_i^{**} \leq 1$ and that technical efficiency measure δ_i^{**} is always equal to or greater than the overall profit maximization efficiency measure α_i^{**}. Using these frameworks, the author undertakes benchmarking exercise for Swiss economy; the results are provided in table 29. First there is a brief description on the types of model used and their underlying technology structure.

NONPAR1 = nonparametric estimates of efficiency assuming a convex technology

NONPAR2 = nonparametric estimates of efficiency assuming a convex technology and CRS

NONPAR3 = nonparametric estimates of efficiency assuming a convex technology and cost minimization

NONPAR4 = nonparametric estimates of efficiency assuming a convex technology, CRS and cost minimization

NONPAR5 = nonparametric estimates of efficiency assuming a convex technology with profit maximization

NONPAR6 = nonparametric estimates of efficiency assuming a convex technology with CRS and variable profit maximization, holding capital fixed

Table 29: Benchmarking							
Year	**NONPAR1**	**NONPAR2**	**NONPAR3**	**NONPAR4**	**NONPAR5**	**NONPAR6**	**PROD**
1984	1.0000	1.0000	1.0000	1.0000	0.9105	0.9219	0.8350
1985	1.0000	1.0000	1.0000	1.0000	0.9792	0.9834	0.8516
1986	0.9937	0.9745	0.9927	0.9733	0.7757	0.8375	0.8339
1987	0.9870	0.9586	0.9865	0.9584	0.7489	0.8138	0.8229
1988	0.9915	0.9737	0.9884	0.9696	0.7917	0.8420	0.8401
1989	1.0000	0.9937	1.0000	0.9937	0.8395	0.8753	0.8647
1990	1.0000	1.0000	1.0000	1.0000	0.8508	0.8805	0.8699
1991	0.9632	0.9608	0.9355	0.9333	0.7655	0.8077	0.8121
1992	1.0000	0.9496	1.0000	0.9343	0.7646	0.8030	0.8093
1993	1.0000	0.9350	1.0000	0.9320	0.7536	0.7913	0.8085
1994	0.9396	0.9380	0.9371	0.9354	0.7677	0.8013	0.8221
1995	0.9578	0.9533	0.9496	0.9448	0.7706	0.8009	0.8288
1996	0.9718	0.9663	0.9578	0.9520	0.7861	0.8114	0.8380
1997	0.9905	0.9815	0.9725	0.9633	0.8314	0.8492	0.8668
1998	0.9850	0.9805	0.9724	0.9671	0.8314	0.8473	0.8658
1999	0.9773	0.9746	0.9671	0.9638	0.8490	0.8611	0.8750
2000	0.9882	0.9854	0.9797	0.9764	0.8930	0.9001	0.9063
2001	0.9965	0.9935	0.9852	0.9813	0.8909	0.8966	0.9045
2002	1.0000	0.9981	0.9849	0.9819	0.8941	0.8986	0.9073
2003	0.9989	0.9978	0.9832	0.9813	0.8845	0.8885	0.9005
2004	0.9898	0.9884	0.9801	0.9780	0.8993	0.9021	0.9107
2005	0.9987	0.9960	0.9907	0.9872	0.9274	0.9289	0.9334
2006	1.0000	0.9974	0.9958	0.9924	0.9644	0.9648	0.9660
2007	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2008	1.0000	1.0000	1.0000	1.0000	0.9955	0.9954	0.9955
Efficient Obs	**10**	**5**	**6**	**5**	**1**	**1**	
Inefficient Obs	**15**	**20**	**19**	**20**	**24**	**24**	

The results from the above table are consistent with the framework established before. It is interesting to note that ultimately we get only one efficient observation and that is in 2007. Also we note that efficiency fell rapidly post 1985 and was one of the lowest during the 3 year recession in the early 90s. Post 2000 there seems to have been a more or less increase in efficiency but it is very likely that after the global economic crisis in 2008 this might start moving in the other direction. Unfortunately the present paper does not cover that time horizon.

11. Conclusion

In this paper we have used the index number approach developed by Diewert and Morrison and Kohli for TFP measurement of Switzerland over the period of 1960-2008. The author also undertook Kohli type decomposition analysis to understand the Swiss growth paradox, which is characterized by juxtaposition of high standard of living and dismal growth performance in the usual economic parameters. The author found that, in accordance with previous literature, Swiss TFP performance has indeed been dismal especially in the 80s and 90s. However as Kohli, the author also found that there has been significant improvement in terms of trade over the last few decades and we find in decomposition analysis that it did play a major role. Another point that is important to factor in is the fact that Switzerland was neutral during WW2 and therefore it wasn’t ravaged by the war as were its other European counterparts. Hence during the 50s and 60s, it already had a higher standard of living. That’s why we see that there hasn’t been much increase in real income in percentage, in comparison to other OECD countries. Also the wage rate, both measures, hasn’t grown significantly, at least not like its European counterparts. This is essentially the conditional convergence hypothesis under neoclassical framework. But it is worth noting that labour income growth seems to be a prominent factor in the income decomposition analysis, more so than TOFT. This might provide future avenue for research, understanding the contribution of labour income growth rate on Swiss real income growth.

In benchmarking efficiency exercise, Swiss economy performance is mediocre at best. The author found that the performance from mid 80s till end of 90s was poor. It is only after the 2003 does the efficiency began to rise but it is likely, given the interconnectedness with global economy, after the economic crisis this optimistic upswing might come to an end. But there is no doubt that Swiss standard of living has improved. Exercise done on the consumer side of the economy yields unambiguous result that both in terms of utility and consumption, adjusting for tax, there has been improvement. One could argue that the increase is not significantly high but one has to remember Switzerland started from a high income position undamaged by WWII.

The author also undertook analysis on the production side of the Swiss economy and find that PMOD4 provides the best result. PMOD4 uses normalized quadratic profit function with CRS and linear splines to model technical progress; the methodology was developed by Diewert etal. Although in some cases elasticities for export go beyond 2 but it’s technical progress parameter comes closest to previous index number estimate, and it has a satisfactory goodness of fit; importantly its nearest competitor PMOD 6 has elasticities going above 5 in the 60s which is even more unlikely. Overall the paper finds that while Swiss economy is probably not the most efficient or productive economy in the world, it has a high standard of living because of its increasing TOFT and higher initial economic status.

Diewert (2000) explains some of the reason why TFP measurement might be slightly off because of imprecision in measuring certain crucial factors; one of them is financial instrument. Currently national accounts do not provide any info on this parameter as statistical agencies on do not have a consensus on how to calculate appropriate prices and quantities for these volatile financial instruments. But financial instruments are crucial part of modern economy; as a matter of fact current economic crisis was fuelled by the widespread destruction of financial assets. Given that Swiss economy is highly dependent on the financial sector and is considered to be one of financial hub of the world, inability to measure this parameter might have lower TFP for Swiss economy significantly.

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