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Testing Okun's Law with Swiss Industry Data

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Abstract

Okun's Law postulates a stable relationship between quarterly output growth and changes in (un)employment. This proposition has so far been tested with macroeconomic data at the highest level of aggregation. The paper goes beyond that in extending the analysis to industry data from Switzerland, applying a method suggested by the International Monetary Fund. Another focus is on whether expansions in production have become more 'jobless' over the most recent business cycle compared to earlier on. This does not seem to be the case in Switzerland, except in the construction industry.

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1. Introduction

Okun's Law famously postulates a stable relationship between quarterly output growth and the quarterly change in the rate of unemployment (Okun, 1962).¹ The Okun's Law coefficient can be regarded as a reduced form parameter incorporating a number of important structural economic parameters pertaining to (optimal) labour supply and demand and the macroeconomic production function, for instance (see Prachowny, 1993; Perman and Tavera, 2005, 2007). The 'Law' tells us how much output growth is needed to reduce unemployment by a certain amount and hence responds to a fundamental concern for macroeconomic policy. It is therefore not surprising that Okun's Law has received a lot of attention in the literature. The main empirical questions were how large the Okun's Law coefficients relating output growth to the change in the rate of unemployment are, whether they are statistically significant, how they vary over time and across countries, and whether they are converging. Arguably, these questions have been answered now to a sufficient degree, even for a country like Switzerland.² So why another paper?

The innovation here against the literature is the focus on the *industry level* of the Swiss economy. Okun's Law is normally tested with macroeconomic data at the highest level of aggregation. This is because the unemployment rate refers to the economy as a whole. In the absence of a captive labour force it is difficult to conceptualise unemployment rates at industry levels. Therefore, I will test what the International Monetary Fund (IMF, 2010) has called the 'employment version of Okun's Law', using the same method as the Fund. This method consists in regressing the growth rate of employment – instead of the change in the unemployment rate – on output growth, applying a Bayesian information criterion for the choice of the optimal lag length.³ Unlike the IMF (2010), however, I will not only examine

¹ In fact, Okun (1962) presents a second version of the law, which postulates a stable relationship between the output gap and the deviation of the unemployment rate from its 'natural' level, taking a rate of 4% as a proxy for the latter.

² Lee (2000), Sögner and Stiassny (2002), Perman and Tavera (2005, 2007), the IMF (2010), and Ball et al. (2013) include Switzerland in their sample of countries.

³ Note that the Swiss State Secretariat for Economic Affairs (SECO) does publish unemployment rates for industries based on the (arguably questionable) notion that a person becoming unemployed still belongs to his or her former industry. Still it is more meaningful to estimate the employment version of Okun's Law for this country because Swiss firms have always been recruiting heavily abroad – in part due to full employment at home. This breaks or at least weakens the output-unemployment nexus to a considerable degree (see also Ball et al., 2013).

the economy as a whole, but also all Swiss industries for which data are available. – Which Swiss industries are subject to Okun's Law in the first place? And how large are the Okun's Law coefficients across industries? These are questions the analysis aims to answer.

Furthermore, I will track the Okun's Law coefficients for Switzerland over time. Are they becoming smaller or larger? And are there differences across industries? There is a recent debate on whether output growth is becoming 'jobless'. This would imply that the Okun's Law coefficients on GDP growth are declining over time. Using the IMF's method, Basu and Foley (2013) calculate Okun's Law coefficients for the nine complete post-War U.S. business cycles and test whether the coefficients are significantly smaller over the most recent business cycle (2001Q1-2007Q4) compared to the earliest (1948Q4-1953Q2). Basu and Foley find evidence for such a decline.⁴

However, there is reason to believe that the Swiss case could be different. First of all, the U.S. seems to be a special case among advanced economies with respect to 'jobless growth'. This catchword came up in the 1990s after Gordon and Baily (1993) had pointed out that during the recovery from the 1990-1991 recession, almost no new jobs had been created in the U.S. Instead, productivity had burst, and employment had been further reduced in the initial stage of the recovery. Gordon (2010) argues that the same pattern re-emerged after the 2001 and the 2007-2009 recessions.⁵ European countries, on their part, saw rising unemployment from the mid-1970s onwards despite some growth in Gross Domestic Product (GDP).⁶ Starting around 1995, however, employment growth accelerated in Europe, resulting in a reduction in unemployment in many countries until the onset of the Great Recession. Mourre (2006) attributes this (amongst other things) to the inception of labour market reforms in these countries.

⁴ Unlike the IMF (2010), Basu and Foley (2013) prefer to link the empirical model to the Kaldor-Verdoorn (KV) literature instead of the literature on Okun's Law (OL). Both assignments could be questioned. The OL literature normally studies the relationship between output growth and changes in the rate of unemployment while the KV literature studies the relationship between output growth and productivity growth. Whether a study of the relationship between output growth and employment growth is closer to the OL or to the KV tradition seems to be a matter of taste.

⁵ Therefore, in the U.S. the notion of 'jobless recoveries' is more prominent than the notion of 'jobless growth', see Groshen and Potter (2003), Schreft and Singh (2003), Schreft et al. (2005), Koenders and Rogerson (2005), Holmes and Silverstone (2006), and Jaimovich and Siu (2012). Recently, Ball et al. (2013) have disputed the empirical evidence on 'jobless recoveries' in the U.S.

⁶ This pattern has been dubbed 'jobless growth' by Caballero and Hammour (1998).

Looked at from a different angle, these transatlantic differences in employment dynamics are the flip side of differences in productivity growth (see Klump et al., 2008), with the U.S. outperforming Europe from the mid-1990s onward (see Gordon, 2004; van Ark et al., 2008). Given the transatlantic differences in productivity growth, the evidence of declining Okun's Law coefficients in the U.S. could contrast with rising ones in Europe. The findings of the IMF point in this direction. In its Spring 2010 *World Economic Outlook*, the Fund maintains that "the responsiveness of the unemployment rate to changes in output has increased over time for several advanced economies, due to less strict employment protection and greater use of temporary employment contracts" (IMF, 2010, p. 98). This means that more unemployment ensues during recessions, but also that more employment is created during upswings than in the past (contrary to what has been found for the U.S. by Basu and Foley). Switzerland presents a particularly interesting – because intermediate – case. Unlike other European countries, it did not enjoy much of a reduction in unemployment after 1995 because its unemployment rate has always been relatively low. Like other European countries, however, it has experienced low productivity growth (see Siegenthaler, 2012).

The paper is organised as follows. The next section discusses the data used to test Okun's Law, and section 3 explains the methods. Section 4 presents results on whether an Okun's Law-like relationship between output growth and employment growth characterises the Swiss economy as a whole and/or Swiss industries. That section also looks into whether output growth in Switzerland has become more – or less – 'jobless' recently. Section 5 concludes.

2. Data

In Switzerland, two institutions are involved in the publication of National Accounts data. The Swiss Federal Statistical Office (SFSO) has the leading part: it publishes the annual National Accounts. The SFSO's time series for GDP currently covers the period 1990-2012.

Quarterly GDP is published by the State Secretariat for Economic Affairs, in Switzerland known under the acronym SECO. SECO calculates quarterly GDP figures based on models in a timely manner and revises them once the annual figures become available from the SFSO. SECO also has back-cast quarterly GDP for the 1980s based on earlier versions of the System of National Accounts. So the time series for quarterly GDP covers the period 1980Q1-2013Q2 at the time of writing. The series for the value added of Swiss industries are shorter, however: they only cover the period 1990Q1-2013Q2. Appendix A lists all industries for which data are available.

Quarterly employment data are available from the SFSO's establishment survey. These covered the period 1991Q3-2012Q2 at the time of writing. The series for total employment in full-time equivalents (FTE) has been back-cast to 1980Q1 by the Swiss Economic Institute (KOF) based on subsequent versions of the 'employment census' and SFSO's former 'employment index'. For the industries, however, FTE data only cover the period 1991Q3-2013Q2, which is roughly the same as the period for which value added data are available. All data were extracted from KOF's databases and are available on request from the author.

As in related work (e.g. IMF, 2010, Basu and Foley, 2013), a business cycle is defined as the period of time between two peaks in the level of real GDP. The business cycle peaks in the period under investigation were in 1981Q2, 1990Q2, 2001Q2 and 2008Q3 (see Figure 1).⁷ This gives us three complete cycles plus one which is still on-going. This, of course, is a much smaller number than the nine U.S. cycles examined by Basu and Foley (2013).⁸ To make things worse, industry data for the first cycle (covering the 1980s) are not available. So the question of whether the Okun's Law coefficients have changed at the industry level is tackled here by comparing the 2001Q2-2008Q3 cycle with the 1990Q2-2001Q2 cycle.

<Figure 1 around here>

3. Methods

The empirical model for testing the employment version of Okun's Law used by the IMF is given by Equation 1 (see IMF, 2010, Chapter 3, Appendices 3.2 and 3.3):

$$\hat{e}_t = \alpha + \beta \hat{y}_t + \sum_{i=1}^n \gamma_i \hat{y}_{t-i} + \sum_{j=1}^m \delta_j \hat{e}_{t-j} + u_t \quad (1)$$

where \hat{e}_t denotes the growth rate of employment, \hat{y}_t denotes the growth rate of value added (output), and u_t is an error term.

The parameter β measures the contemporaneous (or short-run) effect of a 1 percentage point change in output growth on employment growth. Besides that, we can calculate the long-run effect – which the IMF (2010) calls the 'dynamic beta' (β^*) – from Equation 2:

⁷ The short peak-to-peak cycle between 2001Q2 and 2002Q2 is ignored; instead the whole period from 2001Q1 to 2008Q3 is considered one peak-to-peak cycle.

⁸ Note, however, that the Swiss cycles are longer on average than the U.S. cycles examined by Basu and Foley (37 quarters vs. 27). The shortest U.S. cycle Basu and Foley look at (1957Q3-1960Q3) offers only 13 observations (which is arguably not enough for econometric analysis). The shortest Swiss cycle (2001Q2-2008Q3) offers 30 observations.

$$\beta^* = \frac{(\beta + \sum_{i=1}^n \gamma_i)}{(1 - \sum_{j=1}^m \delta_j)} \quad (2)$$

The dynamic beta measures the effect of a 1 percentage point change in output growth on employment growth completely worked out through time, i.e. it incorporates all lagged effects. The question is how many lags should be considered. I will follow the IMF (2010) in basing the choice of lag lengths on a Bayesian information criterion.

Basu and Foley (2013) argue in favour of dropping the lags of the dependent variable from Equation 1. The reason they give is that, despite their wide use in the literature, dynamic specifications including lags of the dependent variable violate key exogeneity assumptions and render OLS parameter estimates inconsistent. What is more, dynamic specifications like Equation 1 should only be considered if the theory to be tested suggests that the current state of the dependent variable is influenced by its own past states (see Keele and Kelly, 2006).⁹ Okun's Law suggests no such thing, however. It focusses on the impact of current and lagged output growth on employment growth or the change in unemployment, respectively, and not on the impact of past (un)employment on current (un)employment. For these reasons, I will follow Basu and Foley (2013) in dropping lags of the dependent variable. Equation 1 then reduces to:

$$\hat{e}_t = \alpha + \beta \hat{y}_t + \sum_{i=1}^n \gamma_i \hat{y}_{t-i} + u_t \quad (3)$$

and Equation 2 reduces to:

$$\beta^* = \beta + \sum_{i=1}^n \gamma_i \quad (4)$$

Equation 3 will be estimated with OLS unless the Durbin-Wu-Hausman test for regressor endogeneity signals the endogeneity of the growth rate of output. In this case, Two-Stage Least Squares will be used with the major demand components in GDP – aggregate private consumption expenditure, aggregate fixed investment and total government consumption – as instruments.¹⁰ The over-identifying moment conditions will be tested using the *J*-statistic. Appendix B reports results for the regressor endogeneity tests.

As was mentioned in the introduction, Basu and Foley (2013) found evidence that the Okun's Law coefficients are getting smaller over time in the U.S. while the IMF (2010) claims that they have risen in several other rich countries. To test whether the Swiss coefficients have changed in a statistically significant way over subsequent business cycles, I

⁹ Keely and Kelly (2006) note that another reason for including lagged dependent variables is to rid the model of autocorrelation. Basu and Foley (2013) recommend the use of heteroscedasticity and autocorrelation-consistent (HAC) standard errors instead.

¹⁰ Basu and Foley (2013) choose similar instruments for both GDP and industry output.

follow Basu and Foley (2013) in using a t -test. When $\hat{\beta}_1$ and $\hat{\beta}_2$ are estimators for the true (contemporaneous or dynamic) Okun's Law coefficients β_1 and β_2 in the two business cycles, and s_1^2 and s_2^2 are the HAC estimators for the true variances σ_1^2 and σ_2^2 , then the test statistic:

$$t = \frac{(\hat{\beta}_1 - \hat{\beta}_2)}{\sqrt{s_1^2 + s_2^2}} \quad (5)$$

is distributed asymptotically normal under the null hypothesis :

$$H_0 : \beta_1 = \beta_2 \quad (6)$$

Unlike Basu and Foley (2013), who use the (one-sided) alternative hypothesis that the coefficient is larger in earlier business cycles, I will use the (two-sided) alternative hypothesis that the two coefficients are different.

4. Results

4.1 Okun's Law coefficients by industry

The first step is to determine the optimal lag length for the estimation of Equation 3. The decision was taken to determine the optimal lag length for the overall economy and then to apply this lag length to all industries to allow for a comparison of the dynamic betas. So Equation 3 was run with real GDP as the measure for (y) and total employment in full-time equivalents (FTE) as the measure for (e) and lag lengths one to eight. The preferred specification according to the Schwarz Bayesian Information Criterion is the specification with seven lags.¹¹ Varying the lag length below or above seven produced no large differences in the estimated betas.

Table 1 reports Okun's Law coefficients for the Swiss economy as a whole and for Swiss industries. For the total economy, two estimation periods are chosen: the whole observation period 1980Q1-2013Q2 and the shorter period 1990Q1-2013Q2 for which industry value added data are available. (Seven quarters are lost due to the lag structure.) The results suggest that Okun's Law matters for Switzerland. A one percentage point increase in value added growth leads to a 0.3-0.4 percentage point increase in employment growth in the same quarter. A short-run elasticity of 0.3-0.4 percentage points is found not only for overall GDP,

¹¹ This means that more lags are used than in the IMF study. The IMF (2010, p. 101) notes that "(f)or most countries and episodes, the [Bayesian information] criterion suggests the use of fewer than two lags". Basu and Foley (2013) restrict their number of lags to two without testing for optimal lag lengths; so do Ball et al. (2013). Palley (1993) on the other hand, who estimates both the unemployment and the employment versions of Okun's Law for the U.S., uses five lags.

but also for a number of either goods-producing or service-producing industries, such as construction, transportation/information/communication, and insurances. The short-run elasticities in manufacturing and wholesale and retail trade are a bit lower while the elasticities in economic services and in public administration and education are considerably higher. No Okun's Law-like relationship was found for five industries.¹²

<Insert Table 1 around here>

Energy and water supply is the only goods-producing industry for which the coefficient is insignificant. This is intuitive given the low labour-intensity in this industry. Among the service industries, the economic services (real estate, business activities and R&D) have the highest short-run Okun's Law coefficient, followed by public administration including education. While the high labour intensity in public administration and education is obvious, its prevalence in economic services may be less so. Basu and Foley (2013), for instance, blame the growing importance of the sector 'finance, insurance and real estate' (FIRE) in the U.S. for decoupling GDP from employment and hence producing 'jobless growth'. Much of FIRE value added in the U.S., however, is rents and imputed income from owner-occupied housing. This is not the case for the Swiss sector 'real estate, business activities and R&D'. In the Swiss National Accounts, the value added corresponding to rents and homeowners' rent equivalents is collected in the industry 'private households' (NACE Section T) which by definition employs no labour and is therefore not considered here.¹³

With respect to banks, the Swiss data confirm Basu and Foley's finding that there is no connection between value added and employment growth. Value added growth in banking largely depends on the fortunes of the financial markets rather than on labour input.

¹² Attfield and Silverstone (1997) note that a regression in the form of Equation 3 is misspecified if output and employment are cointegrated. So I tested the logs of output and employment for cointegration in all industries, sectors and the overall economy using Johansen's system cointegration test with seven lags and basing the deterministic trend assumption of the test on the Schwarz model selection criterion. The industry 'wholesale and retail trade' is the only one for which the null of no cointegration was rejected in favour of the alternative hypothesis of one cointegrating relation. Following Lee (2000), I estimated a vector error correction model for this industry as a robustness test. I found a coefficient on lagged value added of 0.065, which was not significant at the 5 per cent level however. As Lee (2000) notes, this suggests that the omission of the cointegrating relation does not involve severe bias in estimating the Okun's Law coefficients.

¹³ The inclusion of rents and homeowners rent equivalents in the U.S. services sector may be the reason why Basu and Foley (2013) find a lower responsiveness of employment to output in the services sector than in the goods-producing sector. In Switzerland it is the other way round (see Table 1).

Therefore, measured labour productivity in Swiss banking fluctuates strongly: it crashed in 2000/2001, for instance, and again in 2008. Not so much in insurance, however. The Swiss insurance industry has a significant short-run Okun's Law coefficient of around 0.3 (which falls between the values found for 'wholesale and retail trade and repair of motor vehicles' and 'transport, storage, information and communication'). This means that output growth leads to employment growth in the short run in the insurance industry. Furthermore, the Swiss insurance industry shows a very strong and steady labour productivity growth – in fact the strongest productivity growth of all Swiss industries since 1991. This is peculiar since productivity growth in financial and business services has been found to rank at the bottom in other regions (see Jorgenson and Timmer, 2011). This peculiarity needs to be further researched.¹⁴

Apart from banks, no significant short-run Okun's Law coefficients were found for the following service industries: 'hotels and restaurants', 'health and social work' and 'art, entertainment, recreation and other services'. This is odd – at least on the face of it – because in most of these industries production cannot be increased without raising labour input. Hotels, however, are similar to housing in that the 'services' are delivered by the capital goods (buildings) rather than by the landlords (see Hartwig, 2006). Of course, hotels and restaurants also need employees to produce their services. Obviously, however, the relationship between value added and employment is not very strong.

No such argument can be advanced to explain the absence of an Okun's Law-like relationship between output and employment in the Swiss health sector. Health care is very labour-intensive, therefore Okun's Law should hold here much in the same way as in public administration and education. Note however a peculiarity of the Swiss health-care financing system. The state municipalities (cantons) pay around 50 per cent of the hospital costs which make up around 20 per cent of total health expenditures in Switzerland. These payments count as subsidies and hence do *not* enter the calculation of value added of the health industry. With value added so heavily biased, we cannot expect to find any sensible statistical relationships for this sector.

¹⁴ Upon request, the SFSO pointed to the fact that Switzerland is home to a number of globally active reinsurance companies, which distinguishes the Swiss insurance industry from that in most other countries. If the global reinsurance business thrives in the absence of major damage events this will produce high measured value added (premiums minus indemnities) growth without necessarily creating much employment. The difference between banks and insurances would thus be that the insurance industry does not suffer from cyclical crises and therefore shows a steadier productivity growth than banks.

In ‘art, entertainment, recreation and other services’, a positive relationship between output and employment would also be plausible. By contrast, this industry is the only one in which the short-run beta was significantly *negative* over the better part of the past decade (see Table 3). The dynamic beta, however, is not significantly different from zero.¹⁵ The same goes for the dynamic betas in most other service industries. Only ‘public administration and education’ and ‘wholesale and retail trade’ as well as the two goods-producing industries ‘manufacturing’ and ‘construction’ show a significantly positive dynamic beta.¹⁶

The dynamic betas are also statistically significant for the economy as a whole and for the two major sectors – the goods-producing sector (Sector 2) and the services-producing sector (Sector 3). The betas for the total economy are higher than for both major sectors. This is surprising given that GDP growth is a weighted average of sectoral value added growth. An explanation might be that while the value added of the agricultural sector is included in GDP, agricultural employment is *excluded* from the FTE series used to estimate Equation 3 for GDP because no establishment surveys are run in the Swiss agricultural sector. Since agricultural employment has supposedly been on a steep downward trend since 1990, its omission biases the estimated Okun’s Law coefficients on GDP upward.

4.2 *Have the Okun’s Law coefficients changed?*

Tables 2 and 3 report short-term and dynamic betas for separate business cycles as well as the test statistic given above in Equation 5 for testing the null hypothesis that the betas are the same for subsequent business cycles.¹⁷ As can be seen from the tables, the null can usually not be rejected, neither for the total economy (Table 2) nor for sectors and industries (Table 3). So – contrary to the (opposed) findings of Basu and Foley (2013) for the U.S. and the IMF (2010) for several other advanced economies, but in line with Ball et al. (2013) – there is not much evidence for fundamental changes in the relationship between output growth and employment growth in Switzerland.

¹⁵ The 95% confidence intervals around the estimated dynamic betas were calculated assuming that the lagged variables are pairwise uncorrelated. In this case the variance of the sum of the variables equals the sum of their variances.

¹⁶ In the ‘economic services’ industry (real estate, business activities and R&D), the dynamic beta is significantly positive when the equation is estimated with OLS rather than TSLS. In both industries for which endogeneity bias has been identified as a potential problem, the OLS and TSLS results differ markedly.

¹⁷ Since the business cycle starting in 2008Q3 is not yet complete (and since it still has a relatively small number of observations), it will not be considered.

There is one exception, however: the construction industry. In construction, both the short-term and the dynamic betas have dropped significantly in the most recent business cycle compared to the preceding one. Output growth in construction has hence become more ‘jobless’ recently. The reasons are not easy to pinpoint. Capital stock data at the industry level are not available for Switzerland, yet sketchy evidence suggests that the prevalence of machinery has increased at Swiss construction sites. Especially capital-intensive are the construction sites of the transalpine tunnels: just one giant drill and a few workers to operate it. The construction of the longest Swiss tunnel (beneath the Gotthard massif) – which is to become the world’s longest railway tunnel – started in November 1999, i.e. around the starting point of the most recent complete business cycle. This may have contributed to the reduction in the Okun’s Law coefficients in the construction industry.

<Insert Tables 2 and 3 around here>

5. Conclusion

This paper is one of the first to test Okun’s Law – i.e. the proposition that a stable relationship exists between quarterly output growth and changes in (un)employment – with industry data.¹⁸ Swiss data is chosen to perform this task. The main finding is that an ‘employment version’ of Okun’s Law holds in Switzerland – both at the macroeconomic level and in most industries. A one percentage point increase in value added growth leads to a 0.3-0.4 percentage point increase in employment growth in the same quarter. A short-run elasticity of 0.3-0.4 percentage points is found not only for overall GDP, but also for a number of either goods-producing or service-producing industries, such as construction, transportation/information/communication, and insurances. No short-run Okun’s Law-like relationship was found for energy and water supply, hotels and restaurants, banking, health care, and ‘other services’. In the case of health care, this is probably due to an awkward definition of value added in this industry.

The ‘dynamic’ elasticities taking into account all lagged effects up to a lag length of seven quarters (suggested by the Schwarz Bayesian information criterion) are close to or even slightly above 1 in the economy as a whole, in the services sector and in the industry public administration including education. In other industries, namely manufacturing, construction and wholesale and retail trade, the long-run elasticities are lower. In most service industries, however, the ‘dynamic betas’ are not statistically significant.

¹⁸ Pally (1993) is an early forerunner, and Basu and Foley (2013) are more recent ones.

No evidence for changes in the elasticities over subsequent business cycles was found, except for the construction industry. Why output growth in Swiss construction has become more ‘jobless’ recently needs to be further researched.

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Appendix A: Industry definitions

Industries correspond to the NACE (Nomenclature générale des Activités économiques dans les Communautés Européennes) Revision 2 codes, in Switzerland known as NOGA (Nomenclature Générale des Activités) 2008.

2 Sectors

Goods-producing industries (NACE Sector 2)
Service-producing industries (NACE Sector 3)

12 industries or industry groups

Goods-producing

Manufacturing (NACE Section C)
Energy and water supply (NACE Sections D + E)
Construction (NACE Section F)

Service-producing

Wholesale and retail trade; repair of motor vehicles (NACE Section G)
Hotels and restaurants (NACE Section I)
Transport, storage, information and communication (NACE Sections H + J)
Financial intermediation (NACE Industry 64)
Insurance (NACE Industry 65)
Real estate, business activities and R&D (NACE Sections L + M + N)
Public administration and education (NACE Sections O + P)
Health and social work (NACE Section Q)
Art, entertainment, recreation and other services (NACE Sections R + S)

Appendix B: Regressor endogeneity test results

Table A.1 reports results from the Durbin-Wu-Hausman test of regressor endogeneity (see Durbin, 1954, Wu, 1973, Hausman, 1978). Endogenous regressors are correlated with the

error term, for instance because of reverse causality between the regressor variable(s) and the dependent variable. OLS estimation is invalid in the presence of endogeneity. The most common method to deal with regressor endogeneity is to use instrumental variables, which are correlated with the endogenous regressor(s) but not with the error term. In order to test whether regressors are endogenous, the Durbin-Wu-Hausman test runs a secondary regression in which the endogenous variable(s) is (are) treated as exogenous. The J -statistic of the two regressions are then compared. If they are sufficiently close to each other, the null hypothesis that the relevant regressor(s) is (are) exogenous cannot be rejected. Table A.1 reports p-values for the difference in J -statistics. Large values imply that the J -statistics are similar and that the null of exogeneity hence cannot be rejected.

<Insert Table A.1 around here>

To run the Durbin-Wu-Hausman test, instrumental variables have to be chosen. This is often not a straightforward task. I follow Basu and Foley (2013) in choosing the major demand components in GDP – aggregate private consumption expenditure, aggregate fixed investment and total government consumption – as instruments for both GDP and industry output. The null hypothesis that the instruments are indeed exogenous – i.e. not correlated with the error term – can be tested with a J -test. Large p-values of the J -statistic indicate that the overidentifying restrictions need not be rejected. We can thus assume that the error term is uncorrelated with the instruments. Table A.2 reports the p-values of the J -statistic.

<Insert Table A.2 around here>

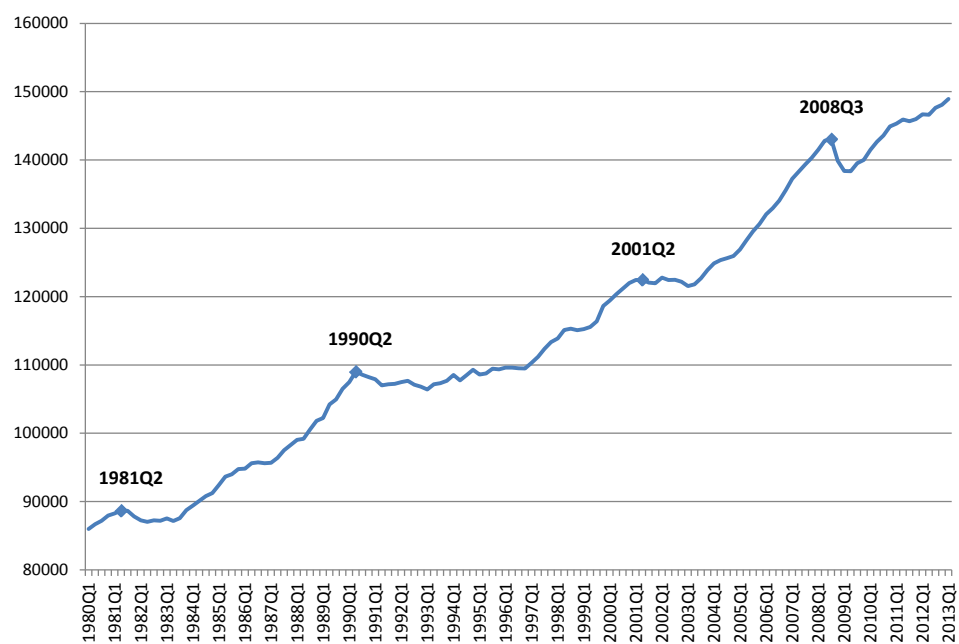
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Figure 1: Swiss GDP, Millions of chained 2010 Francs, seasonally adjusted (peaks marked)



Source: Swiss State Secretariat for Economic Affairs (SECO)

Table 1: Okun's Law coefficients for Swiss industries

	1982-2013		1992-2013	
	Short-run beta	Dynamic beta	Short-run beta	Dynamic beta
Total economy	0.304**	1.083*	0.420**	1.279*
Sector 2			0.223**	0.816*
Sector 3			0.357**	1.011*
Manufacturing			0.148**	0.593*
Energy			0.016	-0.032
Construction			0.400**	0.579*
Trade			0.210**	0.390*
Hotels			0.105	0.325
Transport/IC				
TOLS			0.410**	0.164
OLS			0.035	-0.235
Banks			-0.058	-0.017
Insurances			0.278**	0.240
Economic services				
TOLS			1.039*	1.195
OLS			0.720**	0.585*
Public/Education			0.678**	1.012*
Health			0.007	0.115
Other services			-0.078	0.251

Notes: Equations *Transport/IC* and *Economic services* were estimated with Two-Stage Least Squares because the Durbin-Wu-Hausman test signalled regressor endogeneity at the 5% level (see Table A.1 in Appendix B). Aggregate private consumption expenditure, aggregate fixed investment and total government consumption were used as instruments. OLS estimates are given for comparison. The other equations were estimated with OLS. ** and * indicate statistical significance at the 1% and 5% levels respectively.

Table 2: Testing for a change in the Okun's Law coefficients: Total economy

Short-run beta 1981Q2- 1990Q2	Short-run beta 1990Q2- 2001Q2	Short-run beta 2001Q2- 2008Q3	t-value 2001Q2-2008Q3 vs. 1981Q2-1990Q2	t-value 2001Q2-2008Q3 vs. 1990Q2-2001Q2
0.069	0.503**	0.260**	-0.837	1.237
Dynamic beta 1981Q2- 1990Q2	Dynamic beta 1990Q2- 2001Q2	Dynamic beta 2001Q2- 2008Q3	t-value 2001Q2-2008Q3 vs. 1981Q2-1990Q2	t-value 2001Q2-2008Q3 vs. 1990Q2-2001Q2
0.635	1.331*	1.128*	-0.901	0.494

Notes: The first three columns report short-run and dynamic betas for the total economy for the three consecutive complete business cycles over the observation period. The entries in the last two columns are the values from the test statistic in Equation 5, where the null hypothesis is that the Okun's Law coefficients (betas) are the same between the most recent business cycle (2001Q2-2008Q3) and the earlier ones. The (two-sided) alternative hypothesis is that they are different. Positive values mean that the coefficients are smaller in the most recent period. ** and * indicate statistical significance at the 1% and 5% levels respectively. Note that, due to the lag structure, the entries for the business cycle 1981Q2-1990Q2 refer to the estimation period 1982Q1-1990Q2.

Table 3: Testing for a change in the Okun's Law coefficients: Industries

	Short-run beta 1990Q2- 2001Q2	Short-run beta 2001Q2- 2008Q3	t-value 2001Q2- 2008Q3 vs. 1990Q2- 2001Q2	Dynamic beta 1990Q2- 2001Q2	Dynamic beta 2001Q2- 2008Q3	t-value 2001Q2- 2008Q3 vs. 1990Q2- 2001Q2
Sector 2	0.329**	0.259**	0.552	1.090*	0.798*	0.722
Sector 3	0.383*	0.289	0.407	1.146*	1.050*	0.166
Manufacturing	0.165	0.246**	-0.745	1.556*	0.792*	1.917
Energy	0.087	-0.004	1.216	-0.112	0.115	-0.634
Construction	0.605**	0.208*	3.215**	1.015*	-0.366	2.760*
Trade	0.210	0.258	-0.676	0.352	0.463	-0.255
Hotels	0.071	0.306*	-1.113	0.201	0.577	-0.631
Transport/IC	0.122	0.036	0.499	0.214	-0.587	1.635
Banks	-0.033	-0.106	0.645	0.009	0.025	-0.055
Insurances	0.324**	0.288*	0.208	0.262	0.400	-0.332
Economic services	0.829*	0.696**	0.369	0.821	0.726*	0.157
Public/Education	0.376	0.732**	-1.036	1.482	1.194*	0.283
Health	0.032	-0.019	0.454	0.170	-0.313	1.400
Other services	-0.030	-0.133**	0.862	0.205	-0.334	1.380

Notes: Columns two and three report short-run betas for Swiss industries for the two consecutive complete business cycles over the observation period. The entries in column four are the values from the test statistic in Equation 5, where the null hypothesis is that the short-run betas are the same between the two business cycles. The (two-sided) alternative hypothesis is that they are different. Positive values mean that the coefficients are smaller in the most recent period. ** and * indicate statistical significance at the 1% and 5% levels respectively. The last three columns report the respective values for the dynamic betas. Note that, due to the lag structure, all entries for the business cycle 1990Q2-2001Q2 refer to the estimation period 1992Q1-2001Q2.

Table A.1: Durbin-Wu-Hausman test results (p-values for the difference in J-statistic)

	GDP	S2	S3	C	DE	F	G	I	HJ	64	65	LMN	OP	Q	RS
1982Q1-2013Q2	0.13														
1992Q1-2013Q2	0.83	0.66	0.36	0.22	0.77	0.92	0.70	0.20	0.01	0.64	0.55	0.05	0.24	0.87	0.37
1990Q2-2001Q2	0.95	0.95	0.30	0.29	0.95	0.29	0.80	0.81	0.79	0.06	0.12	0.38	0.19	0.67	0.87
2001Q2-2008Q3	0.07	0.84	0.06	0.68	0.80	0.56	0.25	0.30	0.39	0.57	0.29	0.88	0.42	0.73	0.37

Notes: The first line gives the NACE codes for the relevant Sectors, Sections and Industries (see the brackets in Appendix A). Aggregate private consumption expenditure, aggregate fixed investment and total government consumption were used as instruments – except for the industries ‘public administration and education’ (Sections OP) and ‘health and social work’ (Section Q), where government consumption was dropped. Due to the lag structure, all entries for the business cycle 1990Q2-2001Q2 – except for the one for the total economy (GDP) – refer to the estimation period 1992Q1-2001Q2.

Table A.2: Test for instrument exogeneity (p-values for the J-statistic)

	GDP	S2	S3	C	DE	F	G	I	HJ	64	65	LMN	OP	Q	RS
1982Q1- 2013Q2	0.50														
1992Q1- 2013Q2	0.11	0.04	0.15	0.03	0.15	0.23	0.63	0.93	0.45	0.49	0.68	0.74	0.78	0.11	0.17
1990Q2- 2001Q2	0.22	0.37	0.53	0.44	0.28	0.27	0.38	0.50	0.38	0.94	0.86	0.58	0.78	0.49	0.14
2001Q2- 2008Q3	0.85	0.31	0.88	0.36	0.31	0.46	0.59	0.58	0.49	0.43	0.58	0.31	0.75	0.60	0.74

Notes: See Table A.1.