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CYCLIC DYNAMICS OF PREVENTION SPENDING AND OCCUPATIONAL INJURIES IN GERMANY: 1886-2009

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ABSTRACT

Since the first two decades of the 20th century figures of fatal and non-fatal workplace accidents in Germany have steeply fallen. This downward trend is paralleled by real prevention expenditures of the German Social Accident Insurance rising twentyfold in the post-war period. Against the background of this long-term development, our study analyzes the short- and medium-run cyclic dynamics of occupational injuries and prevention spending at the aggregate and industry level. We find workplace accident statistics as well as real prevention expenditures to be pro-cyclically co-moving with the business cycle. The series follow the product cycle with a minor lag of several quarters. On the sectoral level, a contemporary co-movement with the cycle is particularly pronounced for the construction, health and chemical industries. In a multi-state analysis, we find that prevention expenditures are asymmetrically related to occupational injuries dependent on the phase of the cycle: In the post-war period, only in economic downturns accident rates are significantly elastic in the short run with respect to changes in prevention spending.

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1. INTRODUCTION

The history of German Social Accident Insurance (SAI) can be traced back to the year 1884, when German accident insurance law ("*Unfallversicherungsgesetz*") was enacted within the framework of the general insurance code ("*Reichsversicherungsordnung*"). The basic structural SAI characteristics of the time are preserved to the present day. Figure 1 indicates that non-fatal workplace accidents covered by SAI in per 1,000 full-time employees terms have steeply fallen since the end of the first decade of the 20th century. Since the end of the second decade of the 20th century this also holds for fatal workplace accidents per 1,000 full-time employees.

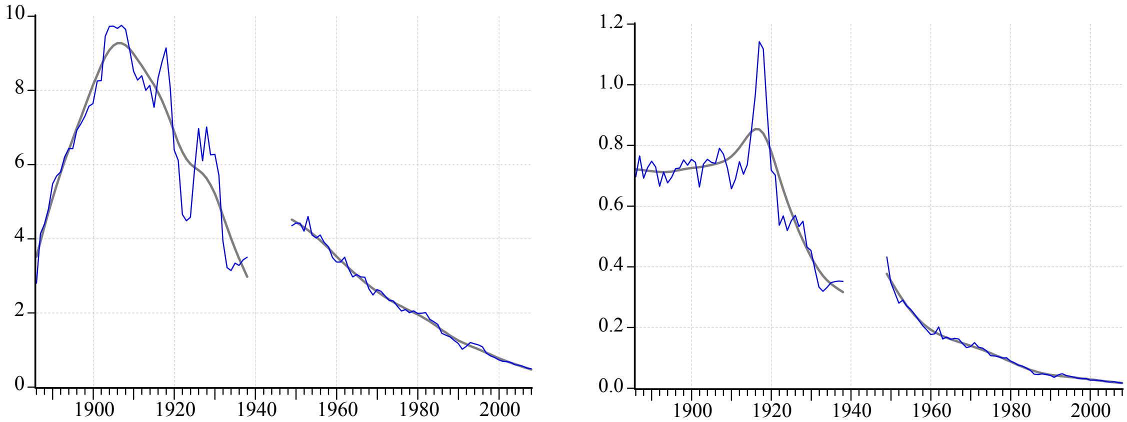

Figure 1: Left panel: Non-fatal workplace accidents per 1,000 full-time employees (blue line). Right panel: Fatal workplace accidents per 1,000 full-time employees (blue line). Notes: Grey line – trend component extracted with a HP(100) filter (Hodrick and Prescott, 1997). Data: Fatal and non-fatal workplace accidents and per 1,000 full-time employees respectively, 1886-1977: Wickenhagen (1980: schemes 1, 3, 4, p. 246, 248-249); 1978-2008: Federal Ministry of Labour and Social Affairs (2009: tables TM1, TM2, p. 145-146); 1949-2008: Business and accounting results of the Commercial and Industrial Accident Prevention and Insurance Association, Association of Commercial and Industrial Workers' Compensation Insurance Carriers.

1.1 Volatility and regime shift in long-run perspective

Figure 1 shows the raw accident series (blue lines) along with their contained trend components (grey lines). We obtained the latter by applying the widely-used HP filter (Hodrick and Prescott 1997). The filtered, i.e., trend-adjusted, time series or cyclical components are shown in Figure 2. Regarding the break in the workplace accident rates that is due to World War II, it becomes obvious that cyclical fluctuations around the trend are more profound in terms of volatility from 1886 to 1938 than in the post-war period.[1] It is also noteworthy that it took several years –until the 1960s– for non-fatal workplace accidents to reach their pre-war level whereas fatal workplace accidents already recovered in the 1950s.

In line with common wisdom, the recent literature (for example, Boone and van Ours, 2006, p. 1084-1085) argues that non-fatal workplace accidents are more likely to be affected by policy measures than are fatal injuries.[2] Following this line of reasoning the decline of volatility of non-fatal workplace accidents can be seen as a long-term success of the early efforts and reforms of the SAI. In particular, this holds for the codification of the

[1] Statistical tests for a decline in volatility of the cyclical components reinforce this visual impression. Detail is available on request from the authors.

[2] It should be noted that Boone and van Ours (2006) make the rather strong assumption of fatal workplace accidents being totally exogenous with regard to policy measures.

Reich's Insurance Code (RIC) from 1911 and the broadening of both provision against risk and compulsory coverage by the 2nd and 6th amendment of the RIC in the years 1925 and 1942.[3]

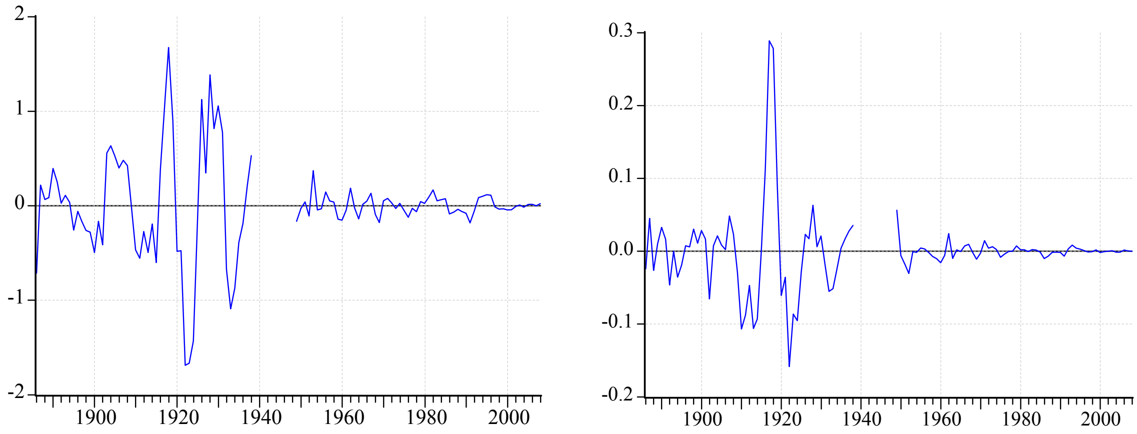

Figure 2: Left panel: Cyclical component of non-fatal workplace accidents per 1,000 full-time employees. Right panel: Cyclical component of fatal workplace accidents per 1,000 full-time employees. Notes: Trend-adjusted with a HP(100) filter (Hodrick and Prescott, 1997). Data: Fatal and non-fatal workplace accidents and per 1,000 full-time employees respectively, 1886-1977: Wickenhagen (1980: schemes 1, 3, 4, p. 246, 248-249); 1978-2008: Federal Ministry of Labour and Social Affairs (2009: tables TM1, TM2, p. 145-146); 1949-2008: Business and accounting results of the Commercial and Industrial Accident Prevention and Insurance Association, Association of Commercial and Industrial Workers' Compensation Insurance Carriers.

It is straightforward to divide our sample in the two periods before and after World War II. This separation can be justified on grounds of a change in the sectoral structure of developed countries as economic historians consensually date the third Kondratieff wave associated with technological revolutions in key industries such as electricity and chemistry from the end of the 19th century to the end of World War II. The fourth Kondratieff wave that is associated with major innovations in microelectronics and in the automobile industry is seen to originate in the 1950s (Solomou 1998). In particular, non-fatal occupational injuries reflect the shape of the pre-World War II Kondratieff (see Figure 1, left panel). Classical authors of the long wave literature, in particular, Kondratieff (1925), Schumpeter (1939) and Mensch (1979), supposed the wave to exhibit an average duration of 50 to 60 years. In contrast, the more recent literature sees the long-term cyclical dynamics to be dominated by so-called "Kuznets swings" (Kuznets, 1930) with an average period length of 20 to 30 years (Metz, 1992; Solomou, 1998). The structural breaks due to both world wars certainly obscure the empirical evidence of long wave phenomena relying on German data in this direction ("war shocks and adjustments," Solomou 1988, p. 91).

1.2 Stabilization: A warrantable target of the SAI program?

The modern notion of corporate social responsibility sees firms as socially responsible to not only sustainability in terms of environmental aspects but also in terms of protecting themselves and employees from absenteeism through occupational injuries. How can this concept, implying the intentional stabilization of workplace accidents, be justified from a welfare economics perspective? In other words, can stabilization policies in terms of occupational injury prevention be rationalized? The literature essentially provides two answers to these questions. First, stabilizing workplace accident rates ensures a relatively higher level of certainty with regard to medium-term planning within the firm as well as in the institutional context of SAI. An enhanced planning reliability – in particular, regarding labor as a factor of production – reduces the uncertainty of investment decision-making in the medium-term. This particularly holds for irreversible investments, potentially leading to an increased productivity (Dixit and Pindyck 1994). Secondly, attenuating the occurrence of occupational injuries over time implies an attenuation of hiring and firing and a reduction in the transitory slack of labor, both bearing a

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[3] Of course, this assessment implies that smoothing or stabilization of workplace accidents over time is really a target; cf. Section 1.2.

substantial cost in terms of transaction cost and –more importantly– of a loss in human capital. Alleviating this loss through stabilization prevents an inevitable decline in productivity (Martin and Rogers 1997).

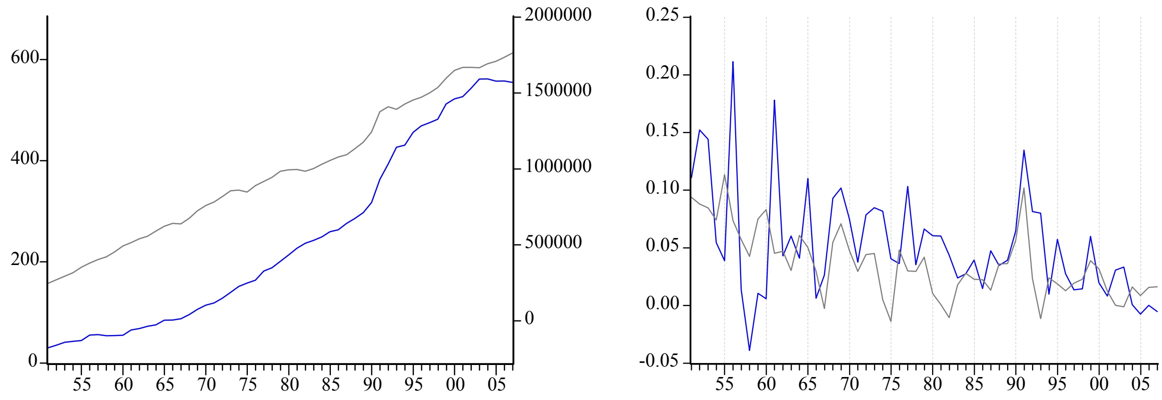

Figure 3: Left panel: Real prevention expenditures (blue line) and real GDP (grey line) in million Euros (at 1990 prices). Right panel: Corresponding growth rates. Data: Association of Commercial and Industrial Workers' Compensation Insurance Carriers; Mitchell (1992), Maddison (1995), IMF.

This reasoning raises the question which alternatives an SAI program can follow to achieve stabilization of accident rates in practice. In addition to the recently promoted philosophy of prevention that is targeted toward establishing an incentive scheme with contribution rebates and premium plans, a countercyclical prevention spending policy seems straightforward. In practice, the latter compares to some extent with the situation of pro-active fiscal policy and implied problems such as timing, implementation lags, and hard-to-assess effectiveness of countercyclical public spending. Hence, from an empirical point of view the task consists of examining, whether German SAI actually followed such a strategy and applied prevention expenditures as an instrument of stabilization in its recent history. To empirically address this issue, we use German SAI time series on "accident prevention and first aid" (account category 59; see Kemény and Scherer 1999). This category includes costs of establishing accident prevention rules, costs of supervising and consulting companies, costs of training, payment to organizations for accident prevention, miscellaneous costs of accident prevention, and costs of first aid. Abstracting from the current decade, Figure 3 clearly shows a pro-cyclical pattern of prevention expenditures by German SAI over the last five decades. A detailed analysis of growth rates (right panel) reveals that prevention spending in real terms is following the growth rates of real GDP with a lag of about one year. The pro-cyclicality between the growth rates of prevention expenditures and non-fatal workplace accidents is rather contemporaneous, i.e., both move within the same phase of the cycle. The latter also holds for fatal workplace accidents per 1,000 employees in the postwar period (not shown here). Overall, a basic descriptive analysis of aggregate time series suggests that there is no evidence of countercyclical prevention spending in the postwar period sample – except for the recent five to ten years.

1.3 Existing literature on the pro-cyclicality of workplace accidents

There is a comprehensive early strand of literature addressing the issue of the relationship between capacity utilization and workplace accidents over the business cycle. As production and working hours typically decrease in recessions, workers' effort levels get lowered, quality of work increases, paralleled by a reduced time span employees are exposed to the risk of occupational injuries (Schuster and Rhodes 1985). Similarly, Smith (1972) argues that overtime work in general increases the number of workplace accidents. Hartwig *et al.* (1997) point out that setting off employees in a recession implies a reduction of less experienced and skilled employees among the work force, inasmuch inexperienced and unskilled workers are usually dismissed at first. As only few new employees join the labor force, the overall share of untrained and inexperienced workers also declines. In the present study, we abstract from recession induced working time reductions and part time contracts, and normalize workplace accident series to full-time employees due to data constraints.

Another explanation of the pro-cyclicality of workplace accidents can be found in the growing literature on strategic over-/under-reporting behavior of employees. The basic idea is developed in Kossoris (1938). If employees fear to lose their jobs, they have a diminished incentive to report workplace accidents. In this context, Leigh (1985) emphasizes two essential side effects of high unemployment. On the one hand, it is plausible to assume that workers showing a high frequency of absenteeism are more likely to get fired in a slump. On the other hand, employees who are still employed during a recession may feel more uncertain about their jobs and, hence, may intensify efforts to avoid absenteeism as well as occupational injuries. The studies of Hartwig *et al.* (1997), Brooker *et al.* (1997), Saloniemi and Oksanen (1998), Boone and van Ours (2006), and Davies *et al.* (2009) find evidence of such reporting behavior ultimately leading to pro-cyclical workplace accidents and/or absenteeism. The usual way to assess the over-/under-reporting hypothesis is to discriminate accidents in different categories of severity. Following Saloniemi and Oksanen (1998), there is no evidence for a pro-cyclicality of fatal workplace accidents. As we will see, this is, however, not concurrently backed by our results. A remarkable early work is Neubert (1971) who in a repeated cross-section, covering the years 1956, 1962, and 1968, analyzes as many as 90 different accident categories for the German manufacturing sector.

A further prominent argument made in the literature points to the dependence of pro-cyclical workplace accidents on the sectoral structure. Accordingly, some industries such as the construction sector are more prone to pro-cyclical occupational injuries than are others. In the case of the construction industry this increased risk is associated with the industry's nature of frequent work place changes. A recent study relying on data that are highly disaggregated in terms of the industrial structure is Bolduc *et al.* (2002). We will account for the sectoral structure and structural changes by considering the following five sectors, including two service industries: construction, metal processing and manufacturing, the chemical industry, transportation, and the health sector.

A final prominent explanation of pro-cyclical occupational injuries emphasizes the moral hazard problem arising if compensation schemes of unemployment insurance and benefits represent more or less perfect substitutes to accident insurance payments (Bolduc *et al.*, 2002).

2. CLASSICAL CORRELATION ANALYSIS

In this section, we will make use of the standard methodology of applied business cycle research established by Kydland and Prescott (1990). This predominantly descriptive approach is based on (i) the use of bandpass or highpass filters – most prominently the HP filter – to determine the cyclical components of the time series at stake and (ii) an extensive correlation analysis, analyzing the lead-lag structure of the cyclical components. We check the robustness of our results by additionally relying on a stochastic trend (first log-differences of the logarithm, i.e., growth rates in first approximation) in step (i). Finally, we also consider an alternative deterministic detrending method (Ravn and Uhlig 2002), which is equivalent to an HP filter with a smoothing weight of $\lambda = 6.25$.[4] If there are significant correlations showing the same lead-lag structure for various filtering methods, the result is referred to as being robust (Canova 1998).

The correlation coefficients reported in Table 1 clearly document a pro-cyclical pattern of non-fatal workplace accidents, which lag real GDP by about one year. We find this lagging of non-fatal occupational injuries both before and after the structural break marked by World War II. The correlations are relatively high and amount to a substantial 37 to 60 percent. In contrast, there is no evidence for a systematic (linear) relationship between fatal workplace accidents and real GDP as indicated by the results for the various filters (cf. Saloniemi and Oksanen 1998). Furthermore, we find real prevention expenditures to be a valid instrument of the business cycle or of a slightly lagging indicator of the cycle, insofar as the series is highly correlated with the cycle component in real GDP at a one period lag. The correlation amounts to values between 42 and 60 percent dependent on the respective filter (Table 2).

4 All of our results are robust with regard to performing the detrending by means of bandpass filtering methods. Precisely we also considered the filters by Baxter and King (1999), A'Hearn and Woitek (2001), and Christiano and Fitzgerald (2003). Detailed results are available on request from the authors.

Table 1: Correlation analysis of workplace accidents and real GDP

Growth rates		GDP(-3)	GDP(-2)	GDP(-1)	GDP	GDP(+1)	GDP(+2)	GDP(+3)
Non-fatal WA:	1887-1938	0.1805	-0.0522	**0.4911**	0.0564	0.1234	-0.1291	0.0276
		(1.185)	(-0.333)	**(3.122)**	(0.479)	(0.863)	(-1.525)	(0.265)
Fatal WA:	1887-1938	0.0306	**-0.2717**	0.2617	-0.0796	0.1803	**-0.2920**	-0.0867
		(0.197)	**(-2.067)**	(1.327)	(-0.497)	(1.177)	**(-2.086)**	(-0.654)
Non-fatal WA:	1949-2007	0.2775	0.1232	**0.6056**	-0.4657	-0.4012	0.1165	-0.1076
		(1.772)	(0.625)	**(4.472)**	(-1.847)	(-1.577)	(0.588)	(-0.632)
Fatal WA:	1949-2007	-0.1422	**0.4282**	0.1531	-0.0127	-0.3547	**0.3260**	-0.1775
		(-1.112)	**(1.974)**	(0.526)	(-0.039)	(-1.764)	**(2.010)**	(-0.730)
HP(100) filter								
Non-fatal WA:	1887-1938	0.1458	-0.2272	**0.4544**	-0.0143	0.1391	-0.1592	-0.0830
		(0.576)	(-1.684)	**(2.886)**	(-0.077)	(0.555)	(-1.144)	(-1.119)
Fatal WA:	1887-1938	-0.0138	-0.3204	0.1062	-0.0755	0.1204	-0.2934	-0.1858
		(-0.059)	(-1.921)	(0.683)	(-0.441)	(0.476)	(-1.226)	(-1.379)
Non-fatal WA:	1949-2007	0.1545	0.0304	0.3612	-0.2056	-0.2518	0.1743	-0.1414
		(1.155)	(0.185)	(1.935)	(-1.239)	(-1.071)	(0.924)	(-0.926)
Fatal WA:	1949-2007	-0.0527	0.2084	-0.0254	0.1847	-0.2511	0.2944	-0.1294
		(-0.463)	(1.359)	(-0.174)	(1.066)	(-1.414)	(1.950)	(-1.100)
HP(6.25) filter								
Non-fatal WA:	1887-1938	0.1039	-0.2101	**0.5546**	0.0341	0.2482	-0.0790	0.2671
		(0.568)	(-1.351)	**(4.238)**	(0.290)	(1.086)	(-0.767)	(2.007)
Fatal WA:	1887-1938	-0.0692	-0.3155	0.1381	-0.0721	0.1591	-0.2690	0.0838
		(-0.343)	(-1.866)	(0.787)	(-0.531)	(0.740)	(-1.296)	(0.615)
Non-fatal WA:	1949-2007	0.1327	0.0594	**0.3666**	-0.1409	-0.0869	0.1377	0.0764
		(1.307)	(0.442)	**(2.213)**	(-0.947)	(-0.514)	(0.881)	(0.637)
Fatal WA:	1949-2007	-0.0448	0.2089	0.0002	0.1807	-0.1772	**0.2686**	-0.0407
		(-0.388)	(1.516)	(0.001)	(1.120)	(-1.035)	**(2.045)**	(-0.317)

Notes: WA – Workplace accidents per 1,000 full-time employees; GDP – real GDP (at 1990 prices); leads and lags are given in parentheses of respective column header; bold type: significant at least at a 5% level; t-statistics based on heteroskedasticity and autocorrelation consistent (HAC) standard errors (Newey and West, 1987); Data: Association of Commercial and Industrial Workers' Compensation Insurance Carriers, Mitchell (1992), Maddison (1995), IMF.

Table 2: Correlation analysis of real prevention expenditures and real GDP, 1949-2007

	GDP(-3)	GDP(-2)	GDP(-1)	GDP	GDP(+1)	GDP(+2)	GDP(+3)
Growth rates							
	0.0063	-0.1736	**0.6069**	-0.1197	0.2480	**-0.5684**	0.2233
	(0.054)	(-0.987)	**(3.202)**	(-0.771)	(1.835)	**(-2.645)**	(1.651)
HP(100) filter							
	0.3934	0.0196	**0.4907**	0.1246	0.1433	-0.1924	-0.0091
	(2.698)	(0.125)	**(2.980)**	(0.620)	(1.001)	(-1.646)	(-0.101)
HP(6.25) filter							
	0.1818	0.0440	**0.4285**	0.1274	0.1031	**-0.2843**	0.0438
	(0.918)	(0.218)	**(2.321)**	(0.553)	(0.599)	**(-2.752)**	(0.442)

Notes: Real GDP (at 1990 prices) and real prevention expenditures (price-adjusted by GDP deflator); leads and lags are given in parentheses of respective column header; bold type: significant at least at a 5% level; t-statistics based on HAC standard errors (Newey and West. 1987); Data: Association of Commercial and Industrial Workers' Compensation Insurance Carriers, Mitchell (1992), Maddison (1995), IMF.

The cyclical component of non-fatal workplace accidents obviously fluctuates in contemporaneous pro-cyclical fashion with the production in the construction sector (Table 3). This confirms the prominent role of the construction industry regarding size and pro-cyclicality of occupational injuries. This stylized fact is also found in the empirical literature based on cross-sectional data, which typically comprises about ten economies and covers a substantially shorter time horizon than the present one (see, for example, Boone and van Ours 2006).

Table 3: Correlation analysis of workplace accidents and production in the construction sector, 1949-2007

	IP(-3)	IP(-2)	IP(-1)	IP	IP(+1)	IP(+2)	IP(+3)
Growth rates							
Non-fatal WA	0.0119	-0.0504	-0.1375	**0.3778**	0.1425	0.0550	0.1062
	(0.139)	(-0.448)	(-0.742)	**(2.287)**	(1.674)	(0.591)	(0.737)
Fatal WA	**0.3737**	**-0.3505**	0.1652	0.0829	0.0232	0.0460	-0.2946
	(3.507)	**(-2.503)**	(1.195)	(0.489)	(0.193)	(0.371)	(-1.757)
HP(100) filter							
Non-fatal WA	0.0199	-0.1659	-0.2857	**0.4024**	0.1333	0.0345	-0.0569
	(0.175)	(-1.005)	(-1.301)	**(2.079)**	(1.444)	(0.282)	(-0.516)
Fatal WA	0.2264	-0.2358	0.1960	-0.0074	-0.0044	0.0535	-0.1007
	(1.489)	(-1.404)	(1.092)	(-0.035)	(-0.026)	(0.439)	(-0.862)
HP(6.25) filter							
Non-fatal WA	-0.0130	-0.1053	-0.2473	**0.3763**	0.1227	0.0312	0.0985
	(-0.131)	(-0.927)	(-1.424)	**(2.130)**	(1.212)	(0.277)	(0.552)
Fatal WA	0.2219	-0.2041	0.1542	0.0082	0.0081	0.0456	-0.1397
	(1.939)	(-1.315)	(1.076)	(0.063)	(0.050)	(0.388)	(-1.036)

Notes: WA – Workplace accidents per 1,000 full-time employees; IP – industrial production (index, 1962 = 100); leads and lags are given in parentheses of respective column header; bold type: significant at least at a 5% level; t-statistics based on HAC standard errors (Newey and West. 1987); Data: Association of Commercial and Industrial Workers' Compensation Insurance Carriers, Hoffmann (1965), Federal Statistical Office (statistical yearbooks).

Table 4 reports the results for the relationship between output fluctuations and non-fatal workplace accidents in the chemical industry, implying a lag of less than or close to one period. The contemporaneous correlation is about 50 percent, which marks a relatively high value compared to coefficients at the one period lag. The results for fatal workplace accidents point to a less pronounced pro-cyclicality with a lag of 2-3 periods.

Table 4: Correlation analysis of workplace accidents and production in the chemical industry, 1949-2007

Growth rates	IP(-3)	IP(-2)	IP(-1)	IP	IP(+1)	IP(+2)	IP(+3)
Non-fatal WA	-0.0550	0.1291	**0.4154**	**0.6650**	-0.0236	-0.2613	-0.2056
	(-0.489)	(1.310)	**(4.880)**	**(8.749)**	(-0.127)	(-1.877)	(-2.299)
Fatal WA	**-0.2214**	**0.4354**	-0.0773	0.2214	-0.1963	0.0337	-0.1100
	(-2.169)	**(2.882)**	(-0.409)	(1.801)	(-1.555)	(0.248)	(-0.815)
HP(100) filter							
Non-fatal WA	-0.0750	0.0543	**0.2914**	**0.4229**	0.0647	-0.1472	-0.0408
	(-0.722)	(0.540)	**(2.802)**	**(4.326)**	(0.422)	(-0.996)	(-0.416)
Fatal WA	**-0.2242**	**0.2696**	0.0707	0.0842	**-0.2805**	0.0855	-0.0142
	(-2.387)	**(2.943)**	(0.873)	(1.298)	**(-3.273)**	(0.690)	(-0.184)
HP(6.25) filter							
Non-fatal WA	0.0385	0.1313	**0.3927**	**0.5171**	0.1295	-0.1513	-0.0553
	(0.346)	(0.959)	**(2.059)**	**(2.917)**	(0.620)	(-0.927)	(-0.406)
Fatal WA	**-0.1559**	**0.2997**	0.1290	0.1365	-0.1968	0.1198	0.0098
	(-2.015)	**(2.196)**	(0.988)	(1.194)	(-1.733)	(0.729)	(0.070)

Notes: WA – Workplace accidents per 1,000 full-time employees; IP – industrial production (index, 1962 = 100); leads and lags are given in parentheses of respective column header; bold type: significant at least at a 5% level; t-statistics based on HAC standard errors (Newey and West. 1987); Data: Association of Commercial and Industrial Workers' Compensation Insurance Carriers, Hoffmann (1965), Federal Statistical Office (statistical yearbooks).

The correlation coefficients of Table 5 reveal that non-fatal workplace accidents in the health sector follow real prevention spending with a lag of less than one year. Correlations at the first order lag are relatively high, amounting to nearly 50 percent. There is also a significant relationship for fatal workplace accidents. However, the cyclical components of both time series exhibits a substantial phase shift, inasmuch fatal workplace accidents lag real expenditures in the health sector by about three years.

Table 5: Correlation analysis of workplace accidents and real expenditures in the health sector, 1970-2007

Growth rates	EXP(-3)	EXP(-2)	EXP(-1)	EXP	EXP(+1)	EXP(+2)	EXP(+3)
Non-fatal WA	0.0331	-0.0901	**0.4662**	**0.1507**	0.0512	**0.2159**	**0.2310**
	(0.489)	(-1.227)	**(5.130)**	**(1.944)**	(0.696)	**(2.848)**	**(1.987)**
Fatal WA	**0.5400**	-0.0720	-0.0242	**-0.2457**	**0.1710**	-0.0461	-0.1317
	(7.921)	(-1.000)	(-0.839)	**(-4.223)**	**(3.598)**	(-0.844)	(-1.301)
HP(100) filter							
Non-fatal WA	-0.0086	-0.0470	**0.5015**	**0.2012**	0.0408	**0.2992**	**0.4271**
	(-0.153)	(-0.834)	**(6.481)**	**(2.304)**	(0.687)	**(2.156)**	**(2.871)**
Fatal WA	**0.3495**	-0.0107	**0.1784**	**-0.5603**	**0.1816**	0.0407	-0.0866
	(2.323)	(-0.111)	**(4.006)**	**(-5.931)**	**(2.235)**	(0.543)	(-1.210)
HP(6.25) filter							
Non-fatal WA	-0.0352	-0.1101	**0.5089**	**0.1738**	-0.0075	0.2568	**0.3088**
	(-0.451)	(-1.198)	**(4.482)**	**(1.960)**	(-0.078)	(1.568)	**(3.388)**
Fatal WA	**0.5745**	0.1726	**0.2574**	**-0.2882**	**0.3034**	0.1644	0.0118
	(3.859)	(1.408)	**(3.023)**	**(-2.651)**	**(2.573)**	(1.572)	(0.142)

Notes: WA – Workplace accidents per 1,000 full-time employees; EXP – real expenditures (deflated by GDP price index); leads and lags are given in parentheses of respective column header; bold type: significant at least at a 5% level; t-statistics based on HAC standard errors (Newey and West. 1987); Data: Association of Commercial and Industrial Workers' Compensation Insurance Carriers, Hoffmann (1965), Federal Statistical Office (statistical yearbooks).

We abstract from showing corresponding results for the metal and transportation industry. For the latter only a marginal and merely robust pro-cyclical relationship with the cycle in real gross value added (1955-2007) can be found. We also find no clear-cut robust results for the metal processing and manufacturing industries using the cyclic component of the production index as our measure of the sectoral business cycle. An assessment of the cyclical time series properties in the frequency domain leads to qualitatively similar findings. Corresponding results relying on a variety of spectral measures are available on request from the authors.

However, it might be that accident rates react differently to prevention measures depending on the state of the business cycle, that is, whether economic activity reaches a peak or a trough. We conduct a corresponding multi-state analysis in the next section.

3. ESTIMATING SHORT-TERM AND LONG-TERM ELASTICITIES

Before we are going into methodological detail, we should be clear about the following point. The inferential task of assessing the contribution of prevention expenditures by SAI funds to the development of occupational injuries in a specific jurisdiction is problematic. In particular, this is due to the fact that decomposing the contributions of firm-level investments and the contributions of prevention spending by the SAI is virtually impossible. Thus, the reader should be aware that we are not after this type of decomposition, disentangling effects of firm-level investments from effects of SAI funded prevention spendings. Our finding of a rather profound coherency of real prevention expenditures and real GDP reported above (Figure 3, Table 2) rather points in the direction that it is reasonable to also assume a co-integrating relationship between the SAI series and the unobserved firm-level data. However, an omitted variable bias remains, even if firm-level spending and SAI expenditures are co-integrated, that is, share the same stochastic trend.

We recommend the non-specialist reader unfamiliar with the economic concept of an elasticitiy (a dimensionless but local rather than global measure in mathematical terms) and/or with the econometric notion of co-integration to have a look at the technical appendix, where both concepts are sketched. It should also help getting the intuition behind the respective notion.

The following methodology is based on the so-called "dynamic OLS- (DOLS-) model" (Stock and Watson 1993). It has, for example, recently been applied to quantify asymmetric reactions of tax base and tax revenue to cyclical fluctuations in economic activity (Sobel and Holcombe 1996, Bruce *et al.* 2006). In this context, asymmetric refers to different elasticity values dependent on the phase of the cycle, that is, below or above the long-term equilibrium relationship of two series.

In our baseline regressions the DOLS-model is used to estimate the long-term elasticity β_1 from a single equation cointegration relationship of the following form

$$\ln WA_t = \beta_0 + \beta_1 \ln PE_t + \sum_{g=-j}^{j} \gamma_g \Delta \ln PE_{t+g} + \varphi_t , \qquad (1)$$

where *WA* denotes non-fatal workplace accidents per 1,000 full-time employees and *PE* real prevention expenditures. The lag- and lead-operator, i.e., the summation of first order differences Δ for different forward and backward shifts of real prevention expenditures, is employed to adjust for problems of endogenity and autocorrelation. We choose the length *j* of this operator by means of the popular Schwarz-Bayesian information criterion (BIC).

Two short-term effects can occur in each period: Workplace accidents may react to changes of real prevention expenditures *PE* and/or may adjust towards their long-term equilibrium level, based on the assumption that a disequilibrium (ε) exists at the beginning of a period, where

$$\varepsilon_t = \ln WA_t - \beta_0 - \beta_1 \ln PE_t . \qquad (2)$$

These effects can be considered in terms of an error correction model (ECM)

$$wa_t - wa_{t-1} = \alpha_0 + \alpha_1 (pe_t - pe_{t-1}) + \alpha_2 \varepsilon_{t-1} + \eta_t , \qquad (3)$$

where minor letters describe variables in natural log, and η_t represents an independent and identically distributed (i.i.d.) random variable. Coefficient α_1 indicates intra-period effects, i.e., short-term adjustment effects to changes of prevention expenditures. Thus it can be seen as a measure of the short-term elasticity of prevention expenditures. A major concern of our study is to unravel differences between short-term and long-term effects of real prevention expenditures on workplace accidents. The selected econometric specification allows a direct comparison of both effects. The short-term reaction of occupational injuries to prevention expenditures is smaller or larger than the long-term reaction, depending on whether α_1 is smaller or larger than β_1. A further interesting question is how fast workplace accidents move to their (new) long-term equilibrium, which may result due to the changes of prevention expenditures. Coefficient α_2 assesses the speed of adjustment of workplace accidents towards their long-term level, i.e., the proportion of disequilibrium, which is reduced in each period. Thus, the larger the absolute value of α_2 is, the faster workplace accidents equilibrate to the new conditions and move to their long-term equilibrium level, respectively.

In equation (3) the short-term elasticity of workplace accidents with respect to changes of prevention expenditures is the same regardless of whether workplace accidents are above ($\varepsilon_t > 0$) or below ($\varepsilon_t < 0$) their long-term equilibrium level. It implicitly assumes that employees react symmetrically to changes in accident prevention. To allow the reaction to depend on the particular state of the business cycle, the ECM can be modified to account for possible asymmetries

$$\Delta wa_t = \alpha_0 + \alpha_1 \Delta pe_t + \theta_1 (D_t \Delta pe_t) + \alpha_2 \varepsilon_{t\text{-}1} + \theta_2 (D_{t\text{-}1} \varepsilon_{t\text{-}1}) + \upsilon_t, \tag{4}$$

where υ_t is an i.i.d. random variable and D_t a dummy variable, which indicates the position of workplace accidents relative to their long-term (LT) equilibrium. It will take the value zero, if accidents are below their steady state level and a value of one, otherwise.

Table 6 shows the results of our model specification with real prevention expenditures as central explanatory variable. In addition to specifications (3) and (4), we also consider the following modifications

$$wa_t - wa_{t\text{-}1} = \alpha_0 + \alpha_1 (pe_t - pe_{t\text{-}1}) + \alpha_2 \varepsilon_{t\text{-}1} + \alpha_3 UB_t + \alpha_4 CON_t + \eta_t, \tag{5}$$

$$\begin{aligned} \Delta wa_t = \alpha_0 + \alpha_1 \Delta pe_t + \theta_1 (D_t \Delta pe_t) + \alpha_2 \varepsilon_{t\text{-}1} + \theta_2 (D_{t\text{-}1} \varepsilon_{t\text{-}1}) \\ + \alpha_3 UB_t + \alpha_4 CON_t + \upsilon_t \end{aligned}, \tag{6}$$

$$\begin{aligned} wa_t - wa_{t\text{-}1} = \alpha_0 + \alpha_1 (pe_t - pe_{t\text{-}1}) + \alpha_2 \varepsilon_{t\text{-}1} + \alpha_3 UC_t + \alpha_4 UA_t \\ + \alpha_5 CON_t + \eta_t \end{aligned}, \tag{7}$$

$$\begin{aligned} \Delta wa_t = \alpha_0 + \alpha_1 \Delta pe_t + \theta_1 (D_t \Delta pe_t) + \alpha_2 \varepsilon_{t\text{-}1} + \theta_2 (D_{t\text{-}1} \varepsilon_{t\text{-}1}) \\ + \alpha_3 UC_t + \alpha_4 UA_t + \alpha_5 CON_t + \upsilon_t \end{aligned}, \tag{8}$$

$$\begin{aligned} wa_t - wa_{t\text{-}1} = \alpha_0 + \alpha_1 (pe_t - pe_{t\text{-}1}) + \alpha_2 \varepsilon_{t\text{-}1} + \alpha_3 UC_t + \alpha_4 UA_t \\ + \alpha_5 CON_t + \sum_{i=6}^{R} \alpha_i REF + \eta_t \end{aligned}, \tag{9}$$

$$\begin{aligned} \Delta wa_t = \alpha_0 + \alpha_1 \Delta pe_t + \theta_1 (D_t \Delta pe_t) + \alpha_2 \varepsilon_{t\text{-}1} + \theta_2 (D_{t\text{-}1} \varepsilon_{t\text{-}1}) \\ + \alpha_3 UC_t + \alpha_4 UA_t + \alpha_5 CON_t + \sum_{i=6}^{R} \alpha_i REF + \upsilon_t \end{aligned}, \tag{10}$$

where *UB* denotes unemployment benefits, which are an arithmetic average of the sum of the mean standard and mean raised rate of unemployment compensation (*UC*) and unemployment aid (*UA*).[5] The variable *CON* represents the number of full-time employees in the construction sector as a proportion of total full-time employees; see the discussion of the prominent role of the construction industry in Section 1.3. Quantities *UC* and *UA* differentiate the impact of *UB* into unemployment compensation and unemployment aid. Specifications (9) and (10) consider possible structural breaks due to reform efforts and law amendments in the framework of German SAI (REF).

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5 The basic source for the construction of this variable is Lampert (1985, 1990).

Table 6: Estimates of the relations between workplace accidents and real prevention expenditures, Sample???

			Short-term elasticity: asymmetric		Speed of adjustment	
	Long-term elasticity	Short-term ela.: symmetric	Below LT equilibrium	Above LT equilibrium	Below LT equilibrium	Above LT equilibrium
Non-fatal WA	**-0.6544**	**0.3960**	**-0.6065**	**0.4698**	-0.0711	-0.0827
	(-20.913)	**(2.721)**	**(-3.014)**	**(5.611)**	(-0.944)	(-0.098)
Fatal WA	**-0.8690**	0.2626	**-0.9175**	**0.3738**	-0.2871	-0.1560
	(-25.628)	(1.354)	**(-2.434)**	**(3.250)**	(-1.706)	(0.694)
Model (1), (2), (5), (6)						
Non-fatal WA		**0.3403**	**-0.5610**	**0.4438**	-0.1482	-0.0672
		(2.078)	**(-2.732)**	**(4.567)**	(-1.537)	(0.571)
Fatal WA		0.1498	**-1.0954**	**0.3481**	**-0.4867**	-0.2542
		(0.686)	**(-2.373)**	**(2.462)**	**(-2.547)**	(1.070)
Model (1), (2), (7), (8)						
Non-fatal WA		0.3249	**-0.7025**	**0.3846**	-0.1479	-0.0949
		(1.671)	**(-2.706)**	**(4.990)**	(-1.514)	(0.349)
Fatal WA		0.0753	**-1.2471**	**0.2217**	**-0.5824**	-0.2833
		(0.300)	**(-2.639)**	**(2.639)**	**(-2.912)**	(1.322)
Model (1), (2), (9), (10)						
Non-fatal WA		0.1597	**-0.7844**	**0.2427**	**-0.3543**	-0.1164
		(0.823)	**(-2.586)**	**(3.738)**	**(-3.093)**	(1.629)
Fatal WA		-0.0192	**-1.8875**	**0.1009**	**-0.6080**	-0.3630
		(-0.075)	**(-3.420)**	**(3.473)**	**(-3.243)**	(0.972)

Notes: Fatal and non-fatal workplace accidents per 1,000 full-time employees; bold type: significant at least at a 5% level; t-statistics based on HAC standard errors (Newey and West. 1987); an empirical model consists of the listed four equations, which are given in the text, respectively.

On the base of results summarized in Table 6, it can be stated that SAI's real prevention expenditures actually reduced workplace accidents in the long-term for the postwar period. Our highly significant estimates of long-term elasticities imply that real expenditures for accident prevention amounting to 14.04 billion Euros reduced the number of non-fatal workplace accidents by about 1.57 million accidents and the number of fatal workplace accidents by about 106,124 accidents (see column 1 in Table 6).

Estimates of the symmetric short-term reactions of non-fatal workplace accidents remain significant as long as the specifications do not account for the separated impacts of unemployment compensation and unemployment aid as well as the impact of reform efforts of the SAI. For both types of workplace accidents it can be argued that prevention expenditures reduce their occurrence in economic downturns, where we define downturns as negative deviations from the long-term equilibrium level. As the reducing effect (in absolute values) compensates the increasing effect in all specifications and states, we conclude that there is indeed some potential of prevention expenditures to act as a stabilizing instrument..

In the case of fatal workplace accidents, the estimates of the short-term elasticities (absolute values of column 3 in Table 6) exceed the estimate of the long-term elasticity (absolute value of column 1 in Table 6) in all specifications. For non-fatal workplace accidents this is true only in those specifications, which consider the prominent role of the construction sector and the structural changes due to interventions of the SAI.[6] This is a remarkable result because it justifies the use of prevention expenditures as a stabilizing instrument also in the short- and medium-term. This stronger short-term effect holds for fatal workplace accidents even if one accounts for the fact that the previous prevention expenditure policy exhibited a destabilizing effect above the equilibrium path. Nevertheless, in the case of fatal workplace accidents this counteracting effect remains of such marginal order (in our preferred last specification) that the net effect still outweighs the long-term effect in the medium run. This does not apply for non-fatal occupational injuries. As expected, the estimate of the long-term elasticity exceeds the net effect of the corresponding asymmetric short-term elasticities.

Overall, specifications (1), (2), (9), and (10) provide the best fit for both fatal and non-fatal workplace accidents. The model explains about one quarter of total variation in accidents series for the postwar period. Based on these estimated asymmetric elasticities, we find that an increase of real prevention expenditures in an economic downturn by one percent reduces (fatal) workplace accidents by 0.8 (1.9) percent. It should be noted that elasticities are a local measure, i.e., they vary over combinations of accidents and expenditures at which they are to be quantified. A calculation with the corresponding means of observations implies the following statement: An increase of real prevention expenditure in an economic downturn by one million Euros reduces the record of workplace accidents on average by 157 non-fatal (and by about 19 fatal) workplace accidents in the group of full-time employees.[7]

4. CONCLUSION

This paper investigated the interplay of the business cycle with workplace accidents and prevention expenditures. We can summarize three main findings. First, we find a significant decrease of the volatility of non-fatal workplace accidents in the period after the Second World War, which we interpret as long-term success of the early efforts and reforms of German SAI. Secondly, real prevention expenditures show a highly significant, negative long-term effect on workplace accidents in the postwar period. Finally, in the short run accident prevention has also a significant, though asymmetric, effect, which reduces occupational injuries in economic downturns. We see one reason for the latter result in the fact that in a downturn the work force is reduced to high-quality employees with a long-term perspective in firms who are more receptive, motivated, and able to implement and realize the prevention measures initiated by SAI programs. We carefully interpret our results as lending support to an asymmetric countercyclical policy, which in any case should be paralleled by the implementation of efficient incentive schemes of contribution rebates and state-dependent premium plans.

Technical Appendix

The economic concept of elasticity and how to calculate reported values

Let Δ denote the rate of change of a variable observed at discrete points in time, that is, $\Delta y = y' - y$, where y' = new value of y and y = old value of y, respectively. In the time series context $y' = y_t$, $y = y_{t-1}$, and, hence, $\Delta y/y$ represents what we usually refer to as a growth rate. Growth rates can be approximated by first (natural) log differences, that is

$$\Delta \ln y = \ln y_t - \ln y_{t-1} \approx \frac{y_t - y_{t-1}}{y_{t-1}} .$$

The approximation behind is a so-called Taylor series approximation of first order. Let f represent a real valued function at a specific point y_{t-1}. From approximation theory, a Taylor series expansion is then given by

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6 The following selected set of interventions is included in our estimations: *UV-Neuregelungsgesetz* in 1963, *Maschinenrichtlinie* in 1989, which coincides roughly with German Reunification, the Employment Protection Act as well as the parallel implementation of the Seventh Social Insurance Code (*SGB VII*) in 1996/1997.

7 Although Kemény and Scherer (1999) analyzed this relationship in the period 1960-1999 with a very simple specification, only considering nominal quantities, they identify a symmetric effect, which is very close to the one documented here. According to their calculations, an increase of nominal prevention expenditures by one million Euros reduces the number of workplace accidents by 156 accidents (author's calculations based on converted D-Mark values).

$$f(y_t) = f'(y_{t-1}) + f'(y_{t-1})(y_t - y_{t-1}) + f''(y_{t-1})\tfrac{1}{2!}(y_t - y_{t-1})^2 + f''(y_{t-1})\tfrac{1}{3!}(y_t - y_{t-1})^3 + \dots,$$

where f' denotes the first derivative or gradient of f, f'' the gradient of f' and so forth. If we disregard, in the sense of a first order approximation, all derivatives of f apart from the first derivative, we end up with

$$f(y_t) \approx f'(y_{t-1}) + f'(y_{t-1})(y_t - y_{t-1}).$$

Now, let $f = \ln y_t$. It follows (due to the fact that $\partial(\ln x)/\partial x = 1/x$) that

$$f(y_t) \approx f'(y_{t-1}) + f'(y_{t-1})(y_t - y_{t-1}) \Leftrightarrow \Delta \ln y = \ln y_t - \ln y_{t-1} \approx \frac{y_t - y_{t-1}}{y_{t-1}}. \qquad \text{(A.1)}$$

An elasticity $\eta_{y,x}$ is defined as the ratio of percentage changes of two variables y and x. Hence, it is defined as

$$\eta_{y,x} = \frac{\frac{\Delta y}{y}}{\frac{\Delta x}{x}} = \frac{\Delta y}{\Delta x}\frac{x}{y}. \qquad \text{(A.2)}$$

From (A.1) and our considerations in the first paragraph of this page, it follows that

$$\eta_{y,x} \approx \frac{\partial \ln y}{\partial \ln x}. \qquad \text{(A.3)}$$

We use this approximation extensively in the text. For example, it allows us to interpret coefficient β_1 in equ. (1) as the preventional expenditures (*PE*) elasticity of non-fatal workplace accidents (*WA*). It tells us by how much, in percent, *WA* changes given that we change *PE* by one percent. In this sense, it represents an intensity or measure of reaction as referred to in the text. The appeal of an elasticity $\eta_{y,x}$ lies in its feature of being dimensionless. It tells us by how much variable y changes in percent given that variable x is changed by one percent. As such it is independent of the dimension of quantities (US-\$, Euros, head counts, etc.) of the underlying variables or series y and x. It allows us to compare our findings with the ones of other empirical economic studies (cf. footnote 9). We can use (A.3) to calculate the approximate cumulative effect for the total period that, for example, *PE* had on *WA*. For example, in the paragraph following Table 8, we made the following statement:

> *Our highly significant estimates of long-term elasticities imply that real expenditures for accident prevention amounting to 14.04 billion Euros reduced the number of non-fatal workplace accidents by about 1.57 million accidents and the number of fatal workplace accidents by about 106,124 accidents (see column 1 in Table 6).*

These figures are calculated on the basis of the following amounts and estimates: For our total period of observation, real SAI expenditures for accident prevention amount to 14.04 billion Euros, the number of accidents cumulated over the total period of observations is 2.4 million for non-fatal accidents and 122,123 for fatal occupational injuries, respectively. The correspondingly estimated elasticities (shown in Table 6) are –0.6544 and –0.8690, respectively. Now the product of 2.4 million × 0.6544 = 1.57 million tells us that total preventional spendings of 14.04 billion Euros had an accumulative reducing effect for the total period on non-fatal accidents amounting to 1.57 million accidents. Similarly, the cumulative effect on fatal accidents is calculated from the product 122,123 × 0.869 = 106,124.

However, an elasticitiy is a local and not a global measure in mathematical terms. This is to say that it is in contrast to the slope of a linear function (which is a global measure) not constant for different values of y and x or, in other words, in the y/x-space. This can, for example, be seen from the last multiplicative term in equ. (A.2), which clearly varies for different values of y and x. In other words, if we are not after the mere cumulative effects, we need to calculate an estimate of the short-term elasticity $\hat{\eta}_{y,x}$, for example, at the means of y and x

$$\hat{\eta}_{y,x} = \frac{\Delta y}{\Delta x}\frac{\bar{x}}{\bar{y}},$$

where bars indicate arithmetic means over the sample period. Again, this can best be interpreted referring to a numerical calculation made in the text in the last paragraph of section 3. Let us, for example, calculate the reported figure for fatal accidents. Over our period of observation, the SAI funds spent 242 million Euros in real terms per year for prevention. On average, there were 0.12 fatal accidents per 1,000 full-time employees per year. If we translate this, considering the short-term elasticity estimate (below long-term equilibrium) reported in the last row of Table 6, this implies that an increase (reduction) of 1% of real expenditures, that is, 2.42 million Euros implied a reduction (increase) of $1.8/100 \times 0.12 = 0.00216$ fatal accidents per 1,000 employees. Multiplying this value with the average number of full-time employees over the period of observation (21,770) renders a value of 47 fatal accidents. In other words, other things being equal, an increase (decrease) of 2.42 million Euros in real prevention expenditures reduces (raises) fatal accidents by a number of 47. Hence, an increase of 1 million implies a reduction of 19.42 in fatal accidents.

The econometric concept of co-integration

Ad hoc, we would most certainly assume that there is a "natural" rate of decline in occupational injuries for every post-war industrialized economy due to, among others, positive externalities from technological change reducing workplace injury hazards. Similarly, we would also expect prevention expenditures to make a positive contribution to the rate of decline in occupational injuries through inspections, workplace consultation, worker training, etc. This mere fact does not tell us something about the relationship between the two variables as they just might be following an individual deterministic trend that is negative for the injuries series and positive for the real expenditures series, respectively. Regressing two series with these characteristics on each other would produce a highly significant negative coefficient, high R-squared values and a low Durbin-Watson statistics – a result that is known as spuriousness in the sense of Granger and Newbold (1974).

However, it might just as well be that the two series share a common stochastic trend model in the sense that a linear (or linearized), negative combination of accidents and expenditures exists that is stationary. A common long-run relationship between the two series exists. The series are said to be co-integrated. A series is said to be integrated of order one, i.e., $I(1)$, if it is non-stationary in levels and stationary in first differences. Two series that each are $I(1)$ are technically said to be co-integrated if a linear combination of them exists that is $I(0)$, i.e., stationary.

There are two test stages that precede and parallel our estimates of long-run and (asymmetric) short-run elasticities in section 3. First, we tested all series whether they are integrated of order one. We used standard Augmented Dickey Fuller tests to find that the $I(1)$-hypotheses cannot be rejected at least at a 10% level of significance (detailed test results are available on request from the authors). Second, we throughout find the DOLS residuals φ_t obtained from equ. (1), shown here again as (A.4), to be stationary using the Dickey-Fuller-type test proposed by MacKinnon (1991)

$$\ln WA_t = \beta_0 + \beta_1 \ln PE_t + \sum_{g=-j}^{j} \gamma_g \Delta \ln PE_{t+g} + \varphi_t \,. \qquad \text{(A.4)}$$

Hence, the following condition is met for all analyzed series: A static regression between non-stationary variables x_t and y_t can be identified as a long-run equilibrium if and only if

- the series x_t, y_t are $I(1)$, and
- the residual vector from a static OLS regression of x_t on y_t is stationary.

For this case an $I(0)$ linear combination of x_t, y_t, that is, the residual vector, exists that is stationary. In the linear combination of x_t, y_t, the similar stochastic trends that both series share cancel. This is the case for the accident series and prevention series at stake.

REFERENCES

A'Hearn, B. and U. Woitek (2001), More International Evidence on the Historical Properties of Business Cycles, J*ournal of Monetary Economics* 47, 321-346.

Baxter, M. and R. G. King (1999), Measuring Business Cycles: Approximate Band-Pass Filters for Economics Time Series, *Review of Economics and Statistics* 81, 575-593.

Bolduc, D., B. Fortin, F. Labrecque and P. Lanoie (2001), Workers' Compensation, Moral Hazard, and the Composition of Workplace Injuries, *Journal of Human Resources* 37, 623-652.

Boone, J. and J. C. van Ours (2006), Are Recessions Good for Health?, *Journal of Health Economics* 25, 1069-1093.

Brooker, A.-S., J. W. Frank and V. S. Tarasuk (1997), Back Pain Claim Rates and the Business Cycle, *Social Science Medicine* 45, 429-439.

Bruce, D., W. F. Fox and M. H. Tuttle (2006), Tax Base Elasticities: A Multi-State Analysis of Long-Run and Short-Run Dynamics, *Southern Economic Journal* 73, 315-341.

Canova, F. (1998), Detrending and Business Cycle Stylized Facts, *Journal of Monetary Economics* 41, 475-512.

Christiano, L. J. und T. J. Fitzgerald (2003), The Band Pass Filter, *International Economic Review* 44, 435-465.

Davies, R., P. Jones and I. Nunez (2009), The Impact of the Business Cycle on Occupational Injuries in the UK, *Social Science and Medicine* 69, 178-182.

Dixit, A. K. and R. S. Pindyck (1994), *Investment under Uncertainty*, Princeton: Princeton University Press.

Federal Ministry of Labour and Social Affairs (2009), *Sicherheit und Gesundheit bei der Arbeit 2007: Unfallverhütungsbericht Arbeit*, Berlin: Federal Institute for Occupational Safety and Health, Federal Ministry of Labour and Social Affairs.

Granger, C. W. J. and P. Newbold (1974), Spurious regressions in econometrics, *Journal of Econometrics* 2, 111-120.

Hartwig, R. P., Retterath, R. C., Restrepo, T. E. and W. J. Kahley (1997), Workers' Compensation and Economic Cycles: a Longitudinal Approach, *Proceedings of the Casualty Actuarial Society* 84, 660-700.

Hodrick, R. J. and E. C. Prescott (1997), Postwar U.S. Business Cycles: An Empirical Investigation, *Journal of Money, Credit, and Banking* 29, 1-16.

Hoffmann, W. G. (1965), *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts*, Berlin: Springer.

Kemény, P. and K. Scherer (1999), *Steigende Ausgaben für Prävention – Sinkende Arbeitsunfallszahlen: Eine empirische Studie*, unpublished manuscript, Federal Association of Accident Insurers, München.

Kondratieff, N. D. (1925), The Static and Dynamic Views of Economics, *Quarterly Journal of Economics* 39, 575-583.

Kossoris, M. (1938), Industrial Injuries and the Business Cycle, *Monthly Labour Review* 46, 579-594.

Kuznets, S. (1930), *Secular Movements in Production and Prices, Their Nature and their Bearing upon Cyclical Fluctuations*, Boston: Houghton Mifflin.

Kydland, F. E. and E. C. Prescott (1990), Business Cycles: Real Facts and a Monetary Myth, Federal Reserve Bank of Minneapolis, *Quarterly Review* 14, 3-18.

Lampert, H. (1985), *Lehrbuch der Sozialpolitik*, Heidelberg, Berlin, New York: Springer.

Lampert, H. (1990), *Die Wirtschafts- und Sozialordnung der Bundesrepublik Deutschland*, München: Olzog.

Leigh, J. (1985), The Effects of Unemployment and Business Cycle on Absenteeism, *Journal of Economics and Business* 37, 159-170.

MacKinnon, J. G. (1991), Critical Values for Cointegration Tests, in R. F. Engel and C. W. J. Granger (eds.), *Long-run Economic Relationships: Readings in Cointegration*, New York: Oxford University Press, 266-276.

Martin, P. and C. A. Rogers (1997), Stabilization Policy. Learning by Doing and Economic Growth, *Oxford Economic Papers* 49, 152-166.

McKenzie, M. D. (1999), The Impact of Exchange Rate Volatility on International Trade Flows, *Journal of Economic Surveys* 13, 71-106.

Mensch, G. (1979), *Stalemate in Technology: Innovations Overcome the Depression*, Cambridge, Mass.: Ballinger.

Metz, R. (1992), A Re-examination of Long Waves in Aggregate Production Series, in A. Kleinknecht *et al.* (Hrsg.), *New Findings in Long-Wave Research*, London: Palgrave Macmillan.

Neubert, H. (1971), *Unfallschwerpunkte in der gewerblichen Wirtschaft. Ein statistischer Beitrag zur Unfallforschung*, Hauptverband der gewerblichen Berufsgenossenschaften, Bonn, Tübingen: Tübingen Chronik.

Newey, W. and K. West (1987), A Simple Positive Semi-Definite, Heteroscedasticity and Autocorrelation Consistent Covariance Matrix, *Econometrica* 55, 703-708.

Ravn, M. O. and H. Uhlig (2002), On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations, *Review of Economics and Statistics* 84, 371-376.

Saloniemi, A. and H. Oksanen (1998), Accidents and Fatal Accidents – Some Paradoxes,*Safety Science* 29, 59-66.

Schumpeter, J. (1939), *Business Cycles. A Theoretical, Historical and Statistical Analysis of the Capitalist Process*, New York: McGraw-Hill.

Schuster, M. and S. Rhodes (1985), The Impact of Overtime Work on Industrial Accident Rates, *Industrial Relations* 24, 234-246.

Smith, R. S. (1972), Intertemporal Changes in Work Industry Rates, *Proceedings of the 25th Annual Meeting of the Industrial Relations Research Association*, 167-174.

Sobel, R. S. and R. G. Holcombe (1996), Measuring the Growth and Variability of Tax Bases over the Business Cycle, *National Tax Journal* 49, 535-552.

Solomou, S. (1998), *Economic Cycles, Long Cycles and Business Cycles since 1870*, Manchester: Manchester University Press.

Stock, J. H. and M. W. Watson (1993), A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems, *Econometrica* 61, 783-820.

Wickenhagen, E. (1980), *Geschichte der gewerblichen Unfallversicherung. Anlagenband*, München, Wien: Oldenbourg.