Profitability, investment and capital productivity

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Abstract

Capital accumulation is pivotal to produce goods and services. Common knowledge is that entrepreneurs invest because of potential profit. However, the various theoretical frameworks as well as empirical studies are not providing unequivocal evidence of direct causality between profit and investment decisions. In this document we use Granger symetric causality test as well as asymmetric causality test first proposed by (Hatemi-J, 2012). We examine possible causality between profit and investment, profit and unit labour cost and between investment and productivity.

Keywords: Capital productivity, rate of profit, asymmetric causality test.
JEL Codes: E22, O47.

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1 Introduction

Investment in physical capital (equipments) is one of the corner stones in economics. Classical economists such as Smith (1805) or Ricardo (1821) emphasize the importance of investment in economic growth (Stubelj, 2014). This is exemplified in the seminal model of growth proposed by Solow (1956). Indeed, in a model where the supply of labour is exogenous, and depends on the population growth rate, were the technical progress is also exogenous, the economy grows if and only if physical capital is accumulated. There is a common knowledge that firms invest because they expect profit. However, the theoretical literature does not provide such as an unequivocal causality. Indeed, in chapters 11 and 12 of the General Theory of Employment, Interest and Money, Keynes (1936), posits that investment depends on profit expectations. Gupta (1988) argues that the causality running from profit to investments is a paradigm in the neoclassical theory. For Lopez and Mott (1999) the causality is the other way round in Kalecki (1990) and Kalecki (1991). An increase in investment will increase overhall profits of the non-financial corporations sector, spurring more investment, but will also increase productive capacity. Marx (2018) can be seen as an intermediate case, the *falling* rate of profit discourage investments, attracts the economy into stagnation and generates the condition for a rising rate of profit. Last, some other authors propose a two-way causality from profit to investment and then from investment to profit. Such authors are, for example, Robinson (1962) or Asimakopulos (1971).

To date, the results of empirical studies to dizentangle the investment-profit nexus are unclear. Blanchard and Rhee (1993) and Inci et al. (2009) using regressions and causality tests and various definition of profit/earnings show that profit causes investments as well as Bar-Yosef et al. (1987). Whereas, in Gupta (1988) and (Mahdavi and Sohrabian, 1994) the causality runs from investment to profit. For Bong-Soo Lee and Nohel (1997) there is a bidirectional causality from profit to investment and then from investment to profit. The study of Stubelj (2014) is inconclusive, but his main conclusion is in favour of a likely causality running from investment to profit but the author shows that depending on countries/industries investment causes profit, sometimes there is no causality and in few occurrences causality runs from profit to investment. The absence of causality is in contradiction with all the traditional explanation of the investment- profit nexus. However, recently, it is also argued that company follows other goal than profit maximisation, for example, Stockhammer (2006), explains that firms seek the creation of shareholder value before profit. In this case, the absence of causality is plausible.

Most of the empirical studies quoted so far, use Granger causality tests based on VAR or VECM or elaborate on panel regressions. In this document we investigate the direction of causality for Luxembourg using quarterly data from 1995 to 2022[1]. We are not restricting ourself to symmetric Granger causality tests but we are investigating if causality can be asymmetric. In other words, we are examining, for exemple, if only a falling rate of profit only implies a falling rate in investment (in line with Marxian theories). Or, if an increasng rate of profit implies an increasing rate of investment. But also any other combination, such as increasing (decreasing) rate of profit versus decreasing (increasing) investment. To do this, we rely on the causality test presented in Hatemi-J (2012). Our results strongly reject the presence of (asymmetric and Granger-symmetric) causality between the evolution of the profit rate and the evolution of investment. If investment and the rate of profit are not directly linked, other elements might explain the evolution of profit and the rate of profit might impact other important economic indicators.

Indeed, the rate of profit of physical capital is defined as the ratio of profit of firms divided by physical capital stocks. Hein (2014) presents a decomposition of the rate of profit as the product of the share of profit in value added multiplied by capital productivity (value added divided by capital). Thus, a fall in the profit rate can be linked to a decrease in the share of profit in value added and/or by lower capital productivity. Interestingly, Manera et al. (2022) sustain that decrease in capital productivity (that should translate in a decline of the rate of profit if the share of profit in value added remains constant) causes a decrease in the wage share. According to these authors, when firms face a decrease in capital productivity they push wages down in order to maximise the rate of profit. Thus, we test if a decline in the rate of profit causes a decline in the share of wages in value added rather than causing investment. Last we address the question of technology transfer through investments. We examine if gross fixed capital formation causes capital productivity gains by implementing new technologies embodied in new capital stocks or, conversely, if improved capital productivity is an incentive for firms to invest. The idea of technology transfer and productivity spillover is pivotal in foreign direct investment studies (e.g. Newman et al. (2015)).

[1] Granger causality tests are still widely used but are not free from limitations. Granger (1969) recognised that Granger causality was not ”true” causality, whatever that might be, but that it seemed likely to be an important part of the full story. White et al. (2011) propose an interesting discussion to linking Granger Causality and the Pearl Causal Model.

Section 2 presents data and the methodology used to test asymmetric causality. Section 3 analyses the evolution of profit and capital productivity and asymmetric causality tests. The last section concludes.

2 Data and methodology

2.1 Data

The main data sources are the quarterly national accounts published by STATEC (the National Statistical Institute of Luxembourg). Data run from 1995Q1 to 2022Q1. STATEC does not publish and even compute quarterly capital stocks. We use the following procedure to obtain an estimate of net quarterly capital stocks. In a first step we collect the net yearly capital stocks produced by AMECO (K^t_{Ameco}) and we use them as a proxy for the net capital stock of the last quarter of the year. To get the value of capital stock in 1995Q1 ($K^{1995,1}_{ini}$) we use the value of 1994Q4 (yearly value of 1994) and we add the value of gross fixed capital formation of 1995Q1 at constant prices ($I^{1995,1}$).

$$K^{1995,1}_{ini} = K^{1994}_{Ameco} + I^{1995,1} \tag{1}$$

We repeat this computation for each quarter. As a consequence, the value of capital stock in 1995Q4 is higher than the yearly value published by AMECO as we do not take into account the depreciation of capital[2] . We then compute the ratio of our estimated capital stock and the value of capital stock published by AMECO for the fourth quarter.

$$\lambda_t = \frac{K^t_{Ameco}}{K^{t,4}_{ini}} \leq 1 \tag{2}$$

This correction factor is applied to our initial estimate of quarterly capital stocks and we have a *crude* estimate of quarterly net capital stocks ($K^{t,i}$). Then,

$$K^{t,i} = K^{t,i}_{ini} \cdot \lambda_t \tag{3}$$

[2]One could have expected to compute the capital stocks as $K^{1995,1}_{ini} = (1-\delta)K^{1994}_{Ameco} + I^{1995,1}$, where δ is a constant depreciation rate. In national accounts, capital stocks are computed using the perpetual inventory method (OECD, 2001). The method uses a survival function of capital assets and hypotheses on average life times of assets. This method gives estimates that are difficult to re conciliate with a geometric depreciation at a constant rate (see Dey-Chowdhury (2008) for details).

Our procedure insures that the last quarter capital stock is consistent with the yearly value and the quarterly evolution follows the pattern of quarterly investment.

Another important element of this study is profit. We use the gross operating surplus. Gross Operating Surplus (GOS) is the profit of enterprises on the goods and services they produce after they have paid their workers. It is their income from production (Output) less the cost of raw materials, services and overheads (Intermediate Consumption) and less labour costs (Compensation of Employees). Unfortunately, at quarterly level, STATEC publishes an aggregate of gross operating surplus plus mixed income ($GOSMI^{t,i}$) at current value. Gross Mixed Income (GMI) is the income of the self-employed and not profit. However, in yearly accounts GMI and GOS are two separate items. We then compute the yearly ratio of GMI and GOS to split the quarterly aggregate. Then,

$$\xi_t = \frac{GOS^t + GMI^t}{GOS^t} \tag{4}$$

Then,

$$GOS^{t,i} = \frac{GOSMI^{t,i}}{\xi_t} \tag{5}$$

And,

$$GMI^{t,i} = GOSMI^{t,i} - GOS^{t,i} \tag{6}$$

To have $GOS^{t,i}$ and ($GMI^{t,i}$) at constant value we divide the current value by the implicit deflator of value added as in National Accounts a deflator for GOS does not exist (if one uses the implicit deflator of output results are similar). From these data we compute the rate of profit ($r^{t,i}$) as,

$$r^{t,i} = \frac{GOS^{t,i}}{K^{t,i}} \tag{7}$$

The rate of profit can be decomposed, as proposed by Hein (2014), as the product of the profit share and capital productivity. Indeed,

$$r^{t,i} = \frac{GOS^{t,i}}{K^{t,i}} = \frac{GOS^{t,i}}{VA^{t,i}} \cdot \frac{VA^{t,i}}{K^{t,i}} \tag{8}$$

The rate of profit increases if the capital productivity increases and/or the profit share in value added increases. Mechanically, if the profit share increases then the unit labour cost decreases. Trivially,

$$dln(r^{t,i}) = dln(\frac{GOS^{t,i}}{VA^{t,i}}) + dln(\frac{VA^{t,i}}{K^{t,i}}) \tag{9}$$

Last, we compute the income share ($SLC^{t,i}$) as the sum of compensation of Employees, $W^{t,i}$ (that also includes any bonuses, overtime payments, cost of living allowances, clothing allowances, and sales commissions) plus the gross mixed income divided by value added ($VA^{t,i}$). We consider the income of employees and self-employed. Note that $W^{t,i}$, $GMI^{t,i}$ and $VA^{t,i}$ are in constant terms. Then,

$$SLC^{t,i} = \frac{W^{t,i} + GMI^{t,i}}{VA^{t,i} - (taxes\ and\ subsidies\ on\ output)^{t,i}} \tag{10}$$

Dividing the numerator and the denominator by total employment expresses $SLC^{t,i}$ as the ratio of *real* unit labour cost divided by real labour productivity.

$$SLC^{t,i} = \frac{(W^{t,i} + GMI^{t,i})/L^{t,i}}{(VA^{t,i} - (taxes\ and\ subsidies\ on\ output)^{t,i})/L^{t,i}} \tag{11}$$

There is a long lasting debate, at least in Luxembourg, if wages should be in constant terms or at nominal value when computing unit labour costs. Often it is nominal wages that are under scrutiny. This is due to the fact that nominal wage rigidities have often been observed. Calmfors and Johansson (2006) propose several explanation for nominal wage rigidities such as social norms against wage cuts. And, arguably, wage rigidities have been pointed out as one of the cause of unemployment crisis explaining the specific analysis of nominal rather than real wages (Schmitt-Groh and Uribe, 2013). But, as explained by Dickens et al. (2007), unions have the capacity to provide their members with information about inflation expectations, and to explain the importance of maintaining the real income level to workers. In this case, real wages should be analysed. In this study we consider real wages (it also allows us to use data only in constant terms for all indicators).

2.2 Asymmetric causality test

Granger causality test are now standard practice in econometrics (see Shojaie and Fox (2022) for an introduction). In this document, we investigate if the level of investment is explained by the rate of profit or vice versa. We also explore the idea that the falling rate of profit might explain the falling labour share in value added. To do so, we use Granger causality tests but we assume that dynamics might be asymetric between positives and negatives evolutions of economic indicators. Thus, we use asymetric causality tests. Asymmetric causality was first introduced by Hatemi-J (2012). Assume that one is investigating the causality between two integrated variables y_{1t} and y_{2t}. The usual approach is to assume that positive and negative shocks have similar causal impact and that the past of y_{1t} (y_{2t}) explains the current value of y_{2t} (y_{1t}) if there is a Granger causality between y_{1t} (y_{2t}) and y_{2t} (y_{1t}). In the case of asymmetric causality, it is assumed that y_{1t} and y_{2t} are two random walk processes. Thus:

$$y_{1t} = y_{1t-1} + \epsilon_{1t} = y_{10} + \sum_{i=1}^{t} \epsilon_{1i} \tag{12}$$

and,

$$y_{2t} = y_{2t-1} + \epsilon_{2t} = y_{20} + \sum_{i=1}^{t} \epsilon_{2i} \tag{13}$$

Now let split the white noises disturbances terms into their positive and negative components. Let $\epsilon_{1i}^{+} = max(\epsilon_{1i}; 0)$ and $\epsilon_{1i}^{-} = min(\epsilon_{1i}; 0)$ be, respectively, the positive shocks and the negative shocks. Similarly, $\epsilon_{2i}^{+} = max(\epsilon_{2i}; 0)$ and $\epsilon_{2i}^{-} = min(\epsilon_{2i}; 0)$. Trivially,

$$y_{1t} = y_{10} + \sum_{i=1}^{t} \epsilon_{1i}^{+} + \sum_{i=1}^{t} \epsilon_{1i}^{-} \tag{14}$$

and,

$$y_{2t} = y_{20} + \sum_{i=1}^{t} \epsilon_{2i}^{+} + \sum_{i=1}^{t} \epsilon_{2i}^{-} \tag{15}$$

Then each variable can be defined as the sum of cumulative positive and negative shocks. Asymmetric causality test the causal relationship between the two positives (negatives) cumulative shocks and/or between the positives (negatives) cumulative shock and the negatives (positives) cumulative shock of the other time series. This is done, as in Granger, by using a vector autoregressive model of order p. The null hypothesis is non-Granger causality. In the case of asymmetric causality between the positive cumulative shocks, $y_t^{+} = (y_{1t}^{+}, y_{2t}^{+})$ the VAR(p) is:

$$y_t^{+} = \eta + A_1 y_{t-1}^{+} + ... + A_p y_{t-p}^{+} + u_t \tag{16}$$

Then a Wald test investigate if all coefficients for the $y_{2t-j}^{+}, j = 1..., p$ variables are zeros and then the past of y_{2t-j}^{+} does not help to explain the present value of y_{1t}^{+} and one concludes that there is no causality between y_{2t}^{+} and y_{1t}^{+}. The same reasoning applies to test the causality between y^+_{1t} and y^+_{2t}. Hatemi-J (2012) suggests to use the following information criterion to select the lag order (p):

$$HJC = ln(|\widehat{\Omega}|) + j\left(\frac{n^2 lnT + 2n^2 ln(lnT)}{2T}\right), j = 1, ..., p. \tag{17}$$

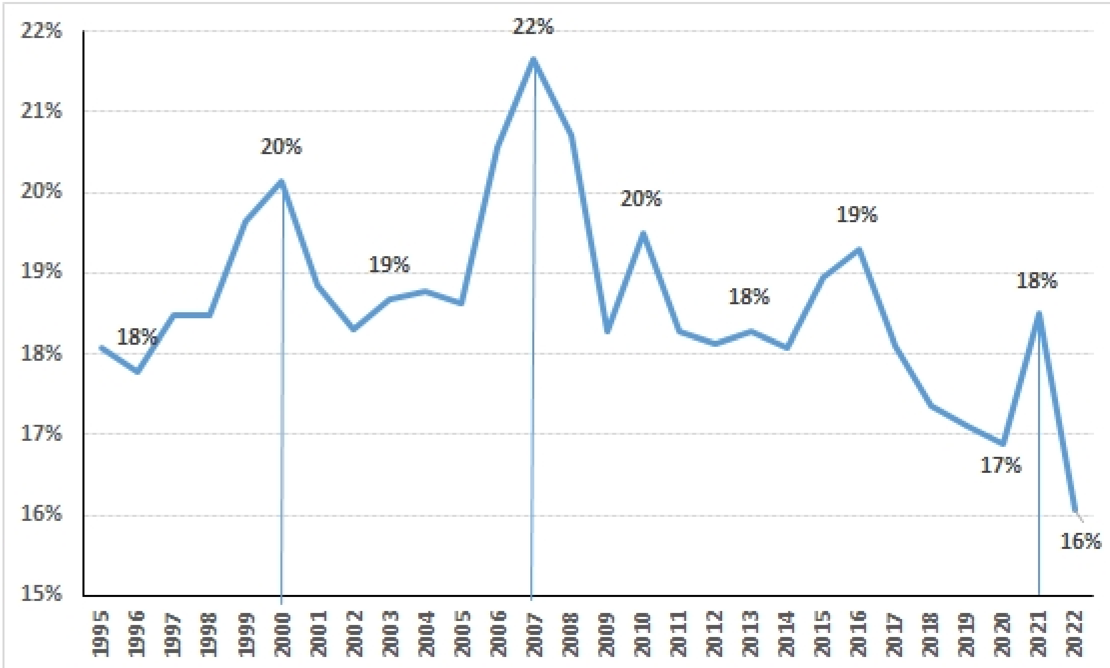
Hatemi-J (2012) indicates that, it is likely that the error terms do not follow a normal distribution and the critical values to be used for the Wald test have to be obtained by bootstrap simulations. First, we estimate the restricted model assuming non-causality (by imposing zero coefficients in the VAR(p) model). Then, we bootstrap the residual δ^* of this model T times. For each bootstrap sample we correct the mean to insure zero mean (δ^{**}). These residuals are used to produce new values for the shocks $y^{*+} = \hat{y}^+ + \delta^{**}$ and the Wald test is performed on each bootstrap sample. The $(\alpha)th$ upper quantile of the bootstrap Wald values give the critical value of the test. The next section presents evolutions of the various economic indicators and causality tests.

3 Results

3.1 Descriptive statistics

Our computations indicate a quarterly average of the profit rate of about 5 percent or 19 percent when annualised (see figure 4). This rate was increasing from 1995 to 2000 (from 18% to 20%) followed by a significant drop during the IT bubble crisis. This rate felt at 19 percent and remained stable up to 2005. An historical pic was reached in 2007 (22%). Since 2007, the profit rate exhibit a decreasing trend with an historical low value in 2022 with a profit rate of 16 percent. In 2021, the profit rate is 18 percent. Chou et al. (2016) using gross operating surplus as an estimate of profit and their own computations of capital stocks find relatively similar results for a set of OECD and transition economies for the period 1995 to 2007. In their study the profit rate has an average value of 11 percent for the United States of America, 15 percent for United-Kingdom, 16 percent for New-Zeeland and 25 percent for Ireland. Note that in Chou et al. (2016), Ireland has a significant higher rate of profit because of an higher profit share and capital productivity compared to other countries (equation 8 shows the link between all these elements).

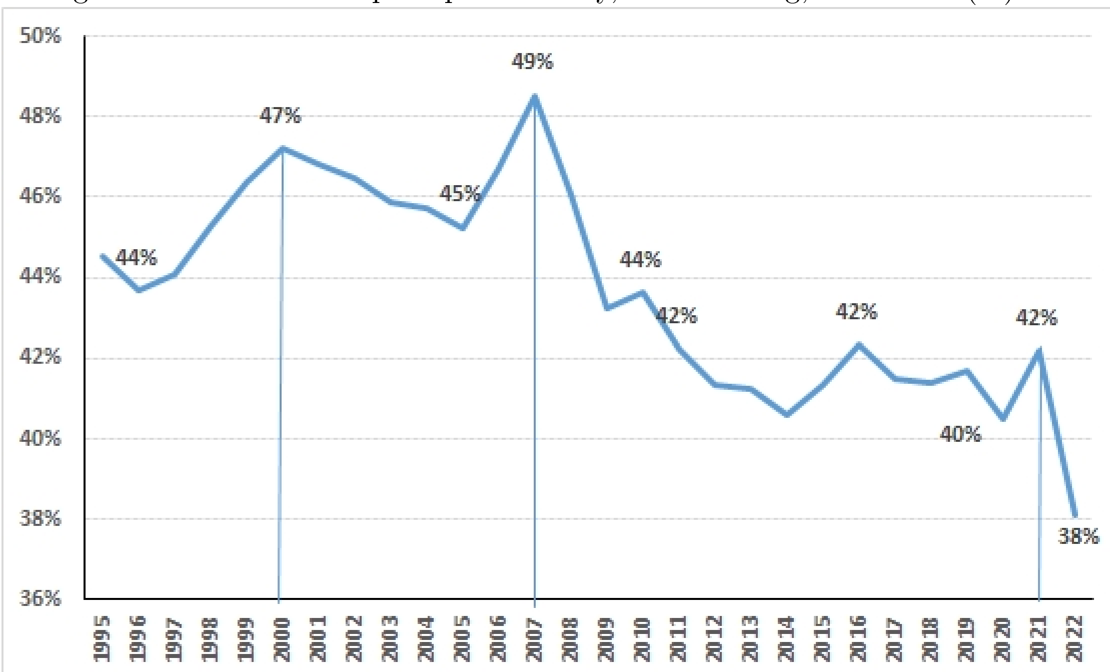
Figure 1: Annualised rate of profit, Luxembourg, 1995-2022 (%)



Note: STATEC National Accounts data.

Beside the two peaks of capital productivity (VA^t/K^t) in 2000 and 2007 (respectively 47% and 48%) it is the decreasing trend of capital productivity since 2007 to 2021 (from 47% to 42%) that is striking (figure 2). What is also worth to notice is that since 2010 up to 2021, capital productivity has remained in between 42 percent and 38 percent with a relatively flat trend (in particular between 2011 and 2014). In 2022 capital productivity falls from 42 percent to 38 percent. Trofimov (2017) compute an higher capital productivity of about 3 percentage points for Luxembourg and for the same years but the trends are similar. Compared to other countries Luxembourg exhibits a higher average capital productivity (44%). In the study of Chou et al. (2016), the average value for highly developed countries is 36 percent, 35 percent for transition economies but 45 percent for developing countries. Both Morkunaite (2019) and Trofimov (2017) find that for most countries capital productivity is decreasing, Luxembourg is not an exception. Morkunaite (2019) provides some possible explanations: capacity underutilisation due to the need for additional investment during a gradual build-up of large projects or the need for resource reorganisation and training. It might also be due to insufficient demand given new production capacities. Or it might be, simply, the result of decreasing marginal returns of capital in some industries.

Figure 2: Annualised capital productivity, Luxembourg, 1995-2022 (%)



Note: STATEC National Accounts data.

In this document we suggest the following explanation for the flat trend in recent years. For the sake of simplicity, assume a Cobb-Douglas production function homogeneous of degree one,

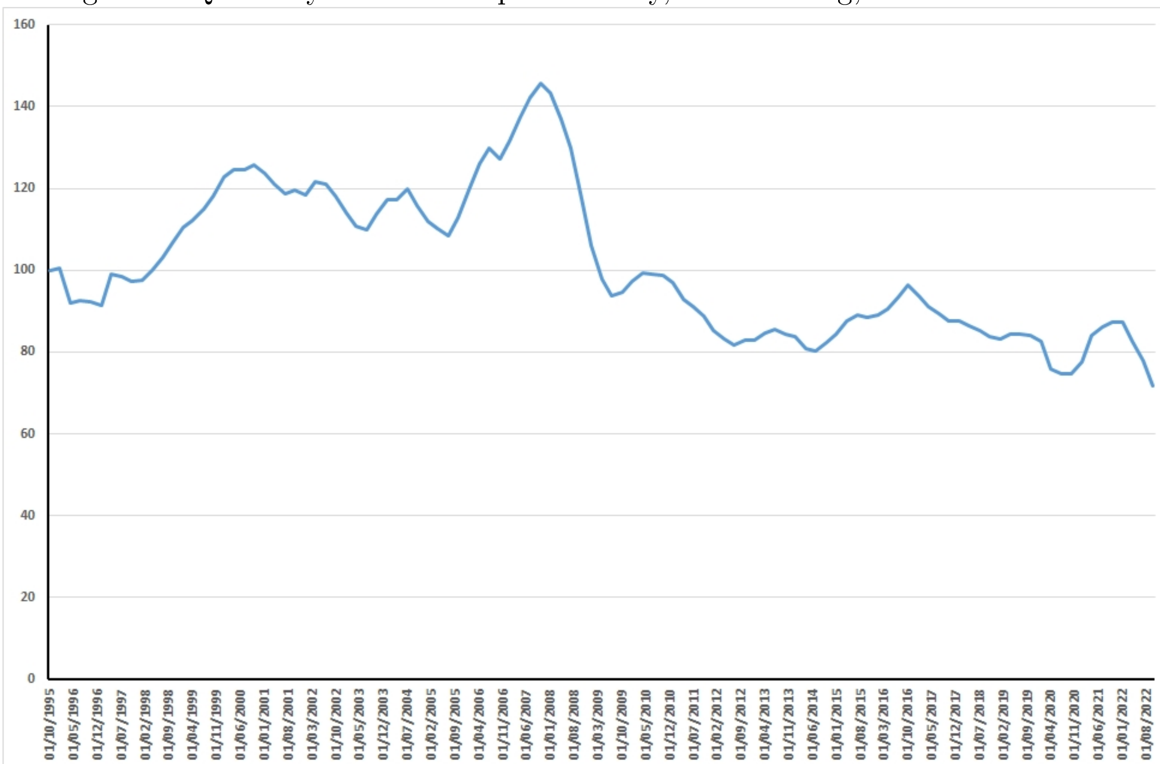
$$Q_t = A_t K_t^{1-\beta} L_t^{\beta} \tag{18}$$

Then,

$$\frac{Q_t}{K_t} = \frac{A_t}{(K_t/L_t)^{\beta}} \tag{19}$$

Capital productivity is the ratio of total factor productivity (TFP) denoted A_t over a function of capital deepening. We compute a crude total factor productivity index using our quarterly data based on growth accounting and income share.

Figure 3: Quarterly total factor productivity, Luxembourg, 1995-2022

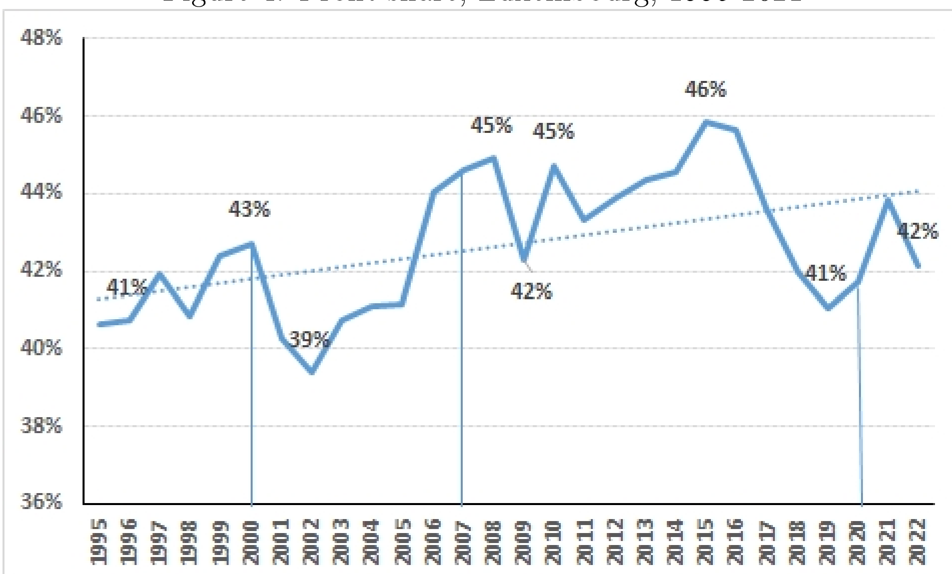


Note: STATEC National Accounts data.

One can see that capital productivity mimic the evolution of TFP. Amjadi et al. (2020) have provided some evidence, using yearly data, that negative and low TFP growth rates in Luxembourg might be explained, in part, by a lack of demand from foreign countries to specific local industries. Yoshikawa (2003) argue that there is a distribution of productivity in equilibrium, and that this distribution is conditioned by real aggregate demand. see Aoyama et al. (2010) for a similar idea. Thus, it is likely, that capital productivity slowdown is partly due to insufficient demand. However, at this stage we cannot exclude the need of training or additional investments to enhance capital productivity.

According to equation 8, another element that might explain the evolution of the rate of profit is the evolution of capital share in total value added. Our data show that, despite two significant drops around 2002 and 2019, the capital share exhibits an increasing trend growing from about 41 percent in 1995 to 45 percent in 2022. similar trends have been observed in many OECD countries (Ellis and Smith, 2007). Then, it seems that the profit share has increased the rate of profit in the long run.

Figure 4: Profit share, Luxembourg, 1995-2021



Note: STATEC National Accounts data.

We now turn to causality to assess if capital productivity explain investment or vice versa and if the falling rate of profit implies a falling labour share.

3.2 Causality analysis

As stated, we examine the Granger and the asymmetric causal relationship between the rate of profit and investment using the test proposed by Hatemi-J (2012). We decompose each variable in positive and negative cumulative sums. We work on quarterly growth rates as the percentage change from the corresponding quarter in the previous year. Note that it implicitly adjusts the seasonality in data (Harris and Yilmaz, 2008). In addition we assume that the first log difference of variables is stationary. We first present Granger causality tests for the three variables of interest the growth rate of capital profitability (Profit), the growth rate of gross fixed capital formation (Investment) and the growth rate of the share of labour in value added (ULC).

Table 1: Granger causality tests.

Line	H0 (all quarters)	Chi-sq	df	Prob.
a1	Investment does not cause Profit	4.936	5	0.42
a2	Profit does not cause Investment	8.527	5	0.13
a3	Investment does not cause capital productivity	0.635	6	0.99
a4	Capital productivity does not cause Investment	16.747	6	0.01
a5	ULC does not cause Profit	18.861	8	0.02
a6	Profit does not cause ULC	12.017	8	0.15
Line	H0 (up to 2006Q4)	Chi-sq	df	Prob.
b1	Investment does not cause Profit	6.176	4	0.19
b2	Profit does not cause Investment	0.298	4	0.99
b3	Investment does not cause capital productivity	17.339	6	0.01
b4	Capital productivity does not cause Investment	3.629	6	0.73
b5	ULC does not cause Profit	15.983	6	0.01
b6	Profit does not cause ULC	10.611	6	0.10
Line	H0 (since 2009Q1)	Chi-sq	df	Prob.
c1	Investment does not cause Profit	2.196	4	0.69
c2	Profit does not cause Investment	9.979	4	0.04
c3	Investment does not cause capital productivity	2.813	6	0.83
c4	Capital productivity does not cause Investment	16.601	6	0.01
c5	ULC does not cause Profit	14.367	6	0.03
c6	Profit does not cause ULC	11.338	6	0.08

Note: Author computations.

Clearly, from table 1, investment decisions and the rate of profit of capital are disconnected (lines a1 and a2). However, if we split the sample, the causality between profit and gross fixed capital formation exist after 2009Q1 (line c2). Interestingly, capital productivity causes investment (line a4) but the results seems to be driven by the causality after the financial crisis of 2007/2008 (line c4). Surprisingly, the causality is inversed before the financial crisis and runs from investment to productivity (line b3). This result is in line with the idea of technology transfer and productivity spillover from investments. On the other hand, the evolution of labour costs in total value added impacts the profit rate (line a5). We cannot ignore even if not significant at the 15 percent level that profit causes ULC (with a probability of 15%, line a6). It might be the case that different dynamics between the positives and negatives components of variables might explain, in some cases, the absence of causality. Thus we compute asymmetric causality tests.

Table 2: Asymmetric Granger causality tests.

Component							
positive	Y	Profit	Investment	Profit	ULC	Productivity	Investment
positive	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	4.652	2.232	2.779	3.652	5.199	2.015
	1%	12.078	12.658	19.061	14.458	19.949	20.920
	5%	9.902	10.405	15.518	11.766	15.969	17.323
	10%	8.878	9.388	13.826	10.426	14.257	15.597
	15%	8.297	8.631	12.879	9.643	13.103	14.459
negative	Y	Profit	Investment	Profit	ULC	Productivity	Investment
negative	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	3.951	4.884	**22.471**	**19.813**	5.643	0.111
	1%	13.579	10.512	23.595	25.988	16.434	16.739
	5%	11.854	8.566	18.968	20.341	13.141	13.781
	10%	10.899	7.577	17.078	17.967	11.839	12.328
	15%	10.272	6.983	15.949	16.219	10.990	11.538
negative	Y	Profit	Investment	Profit	ULC	Productivity	Investment
positive	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	5.231	2.389	0.526	1.379	4.560	3.566
	1%	12.859	10.329	20.278	9.693	16.073	15.239
	5%	10.965	8.548	17.006	7.334	13.202	12.349
	10%	9.919	7.613	15.253	6.253	11.512	11.039
	15%	9.269	7.069	14.154	5.614	10.623	10.235
positive	Y	Profit	Investment	Profit	ULC	Productivity	Investment
negative	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	3.835	3.409	0.064	**7.839**	3.388	1.156
	1%	11.353	12.592	19.467	7.479	19.528	6.854
	5%	9.630	10.413	15.855	5.531	16.264	5.599
	10%	8.726	9.338	14.099	4.589	14.874	5.059
	15%	8.119	8.716	12.915	4.020	13.842	4.749

Note: H0 X does not cause Y.

Table 3: Asymmetric Granger causality tests (up to 2006Q4).

Component							
positive	Y	Profit	Investment	Profit	ULC	Productivity	Investment
positive	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	4.301	2.281	13.913	4.209	3.597	2.846
	1%	16.705	16.989	28.037	29.103	16.504	15.068
	5%	12.567	12.474	21.965	22.966	12.738	11.289
	10%	10.937	10.932	18.916	20.162	11.013	9.717
	15%	9.885	9.923	17.014	18.403	9.978	8.696
negative	Y	Profit	Investment	Profit	ULC	Productivity	Investment
negative	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	3.595	3.619	15.089	8.802	4.441	4.828
	1%	15.411	13.011	37.492	35.886	23.534	16.453
	5%	11.919	9.602	28.857	27.242	17.799	12.143
	10%	10.506	8.226	24.661	23.955	15.613	10.264
	15%	9.573	7.408	22.005	21.649	14.331	9.119
negative	Y	Profit	Investment	Profit	ULC	Productivity	Investment
positive	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	5.038	1.117	13.582	1.165	2.269	1.315
	1%	15.091	11.112	28.836	28.634	23.669	8.656
	5%	11.461	8.102	20.599	19.839	17.532	6.275
	10%	9.581	6.891	17.329	16.234	15.101	5.160
	15%	8.513	6.087	15.457	13.796	13.303	4.488
positive	Y	Profit	Investment	Profit	ULC	Productivity	Investment
negative	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	1.924	3.763	0.351	**19.655**	0.694	1.901
	1%	12.129	19.657	33.715	17.463	12.506	19.745
	5%	9.335	14.407	24.469	12.120	9.666	13.881
	10%	8.038	11.960	20.371	9.861	8.363	11.648
	15%	7.237	10.633	18.092	8.421	7.521	10.153

Note: H0 X does not cause Y.

Table 4: Asymmetric Granger causality tests (since 2009Q1).

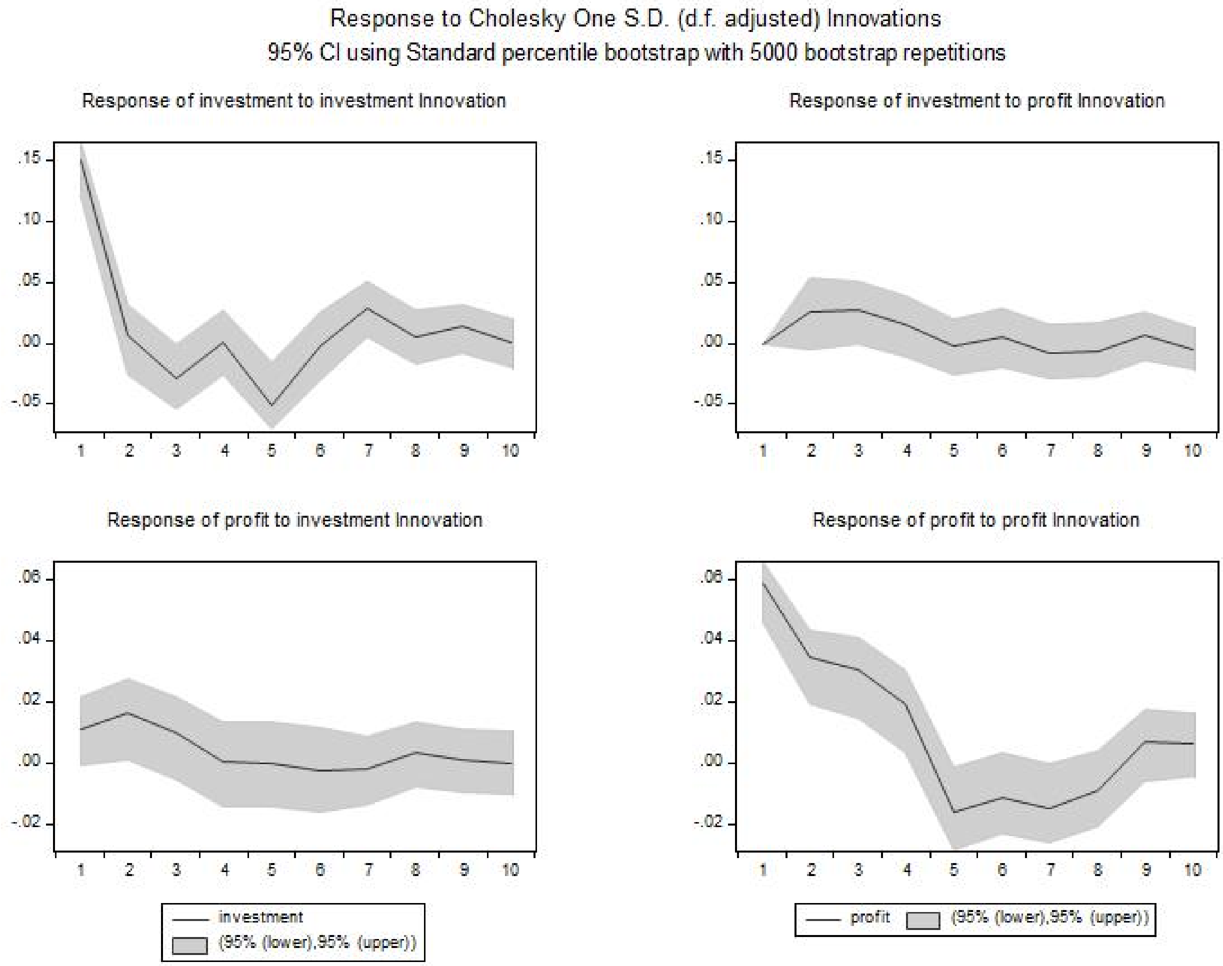
Component							
positive	Y	Profit	Investment	Profit	ULC	Productivity	Investment
positive	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	5.771	0.029	4.454	2.256	2.529	0.347
	1%	12.484	27.718	11.393	14.144	5.714	12.943
	5%	8.846	21.309	9.283	11.157	3.977	10.400
	10%	7.379	18.519	8.070	9.872	3.213	9.202
	15%	6.338	16.990	7.282	9.036	2.687	8.357
negative	Y	Profit	Investment	Profit	ULC	Productivity	Investment
negative	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	0.922	0.001	10.308	2.665	0.253	0.650
	1%	26.902	13.143	32.359	23.943	5.917	6.208
	5%	21.323	9.809	25.553	18.696	4.492	4.313
	10%	18.799	8.148	22.447	16.289	3.759	3.564
	15%	17.054	7.099	20.503	14.738	3.315	3.054
negative	Y	Profit	Investment	Profit	ULC	Productivity	Investment
positive	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	2.551	0.862	0.313	3.522	1.522	0.565
	1%	23.826	21.631	33.383	22.105	7.228	12.003
	5%	18.092	17.072	25.954	15.850	5.435	9.612
	10%	15.817	15.097	22.443	13.121	4.581	8.466
	15%	14.318	13.961	20.272	11.567	4.064	7.684
positive	Y	Profit	Investment	Profit	ULC	Productivity	Investment
negative	X	Investment	Profit	ULC	Profit	Investment	Productivity
	Wald stat.	**8.520**	0.007	0.041	8.070	3.543	0.121
	1%	13.073	16.176	28.134	17.594	8.996	10.145
	5%	10.139	11.919	21.666	12.503	6.926	7.099
	10%	8.759	10.108	18.508	10.076	5.921	5.963
	15%	7.899	8.995	16.759	8.565	5.327	5.307

Note: H0 X does not cause Y.

Only few asymmetric causality test are significant (see table 2 to 4). And in all of these cases, it is the asymmetric causality between the labour share in value added and the rate of profit that is unearthed. After the financial crisis, there is one interesting causality running from negative changes in investment with positive changes in profit. Causality tests do not say the sign of the causality then we compute impulse response functions for these variables, for example, a larger decrease of one variable causes an increase in another variable. The causality test only indicates a statistical link.

[PUT SOME GRAPHS IN APPENDIX]

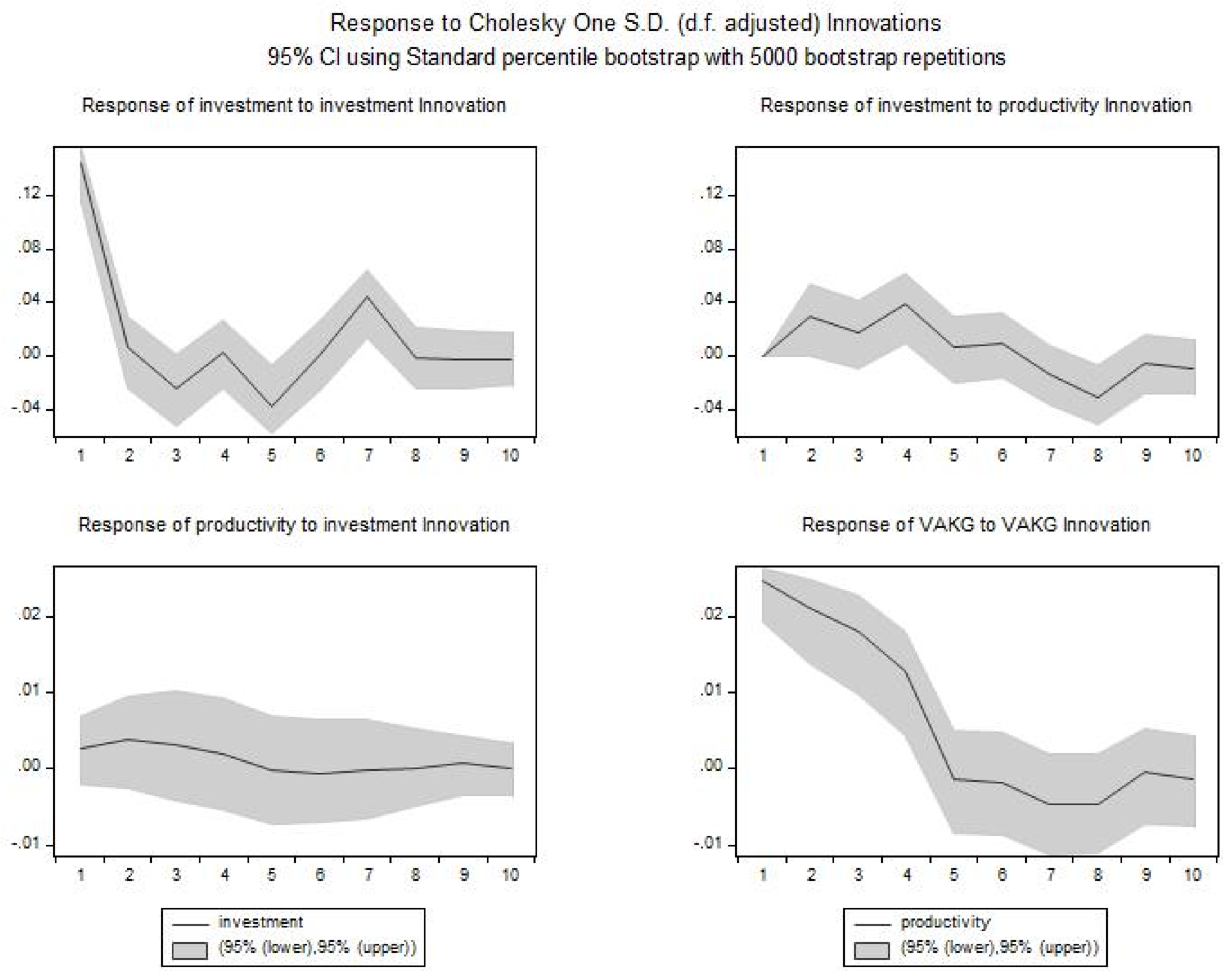
Figure 5: Causality test - full sample



Note: Author computations.

As shown by the causality test (table 1) there is no causality over the full sample between changes in investment and changes in profit (figure 5).

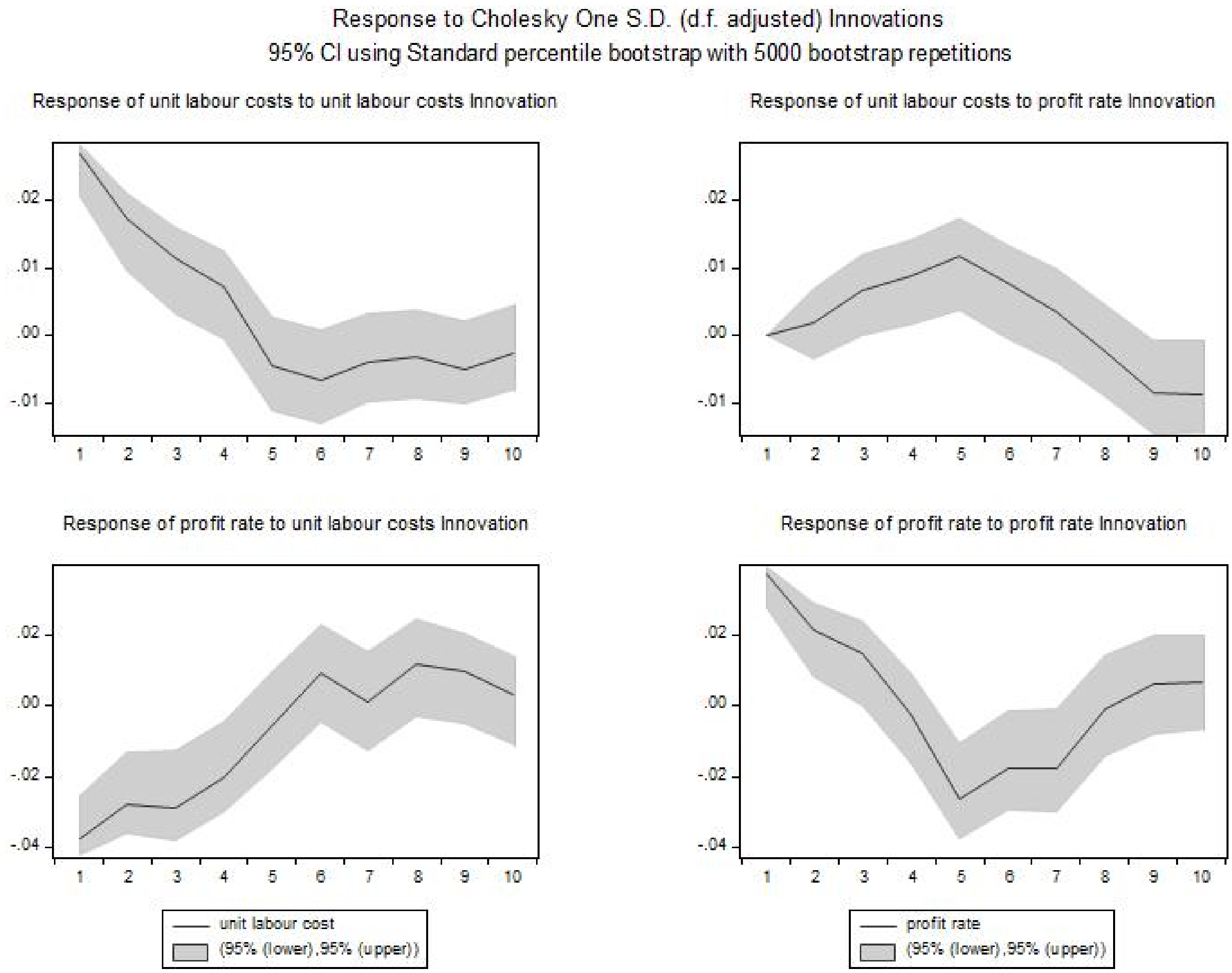
Figure 6: Causality test - full sample



Note: Author computations.

The upper right graphs in figure 6 shows that a positive change in capital productivity raises the growth of investment with a lag of four quarter that is counter-balanced by a slight decrease with a lag of 8 quarters.

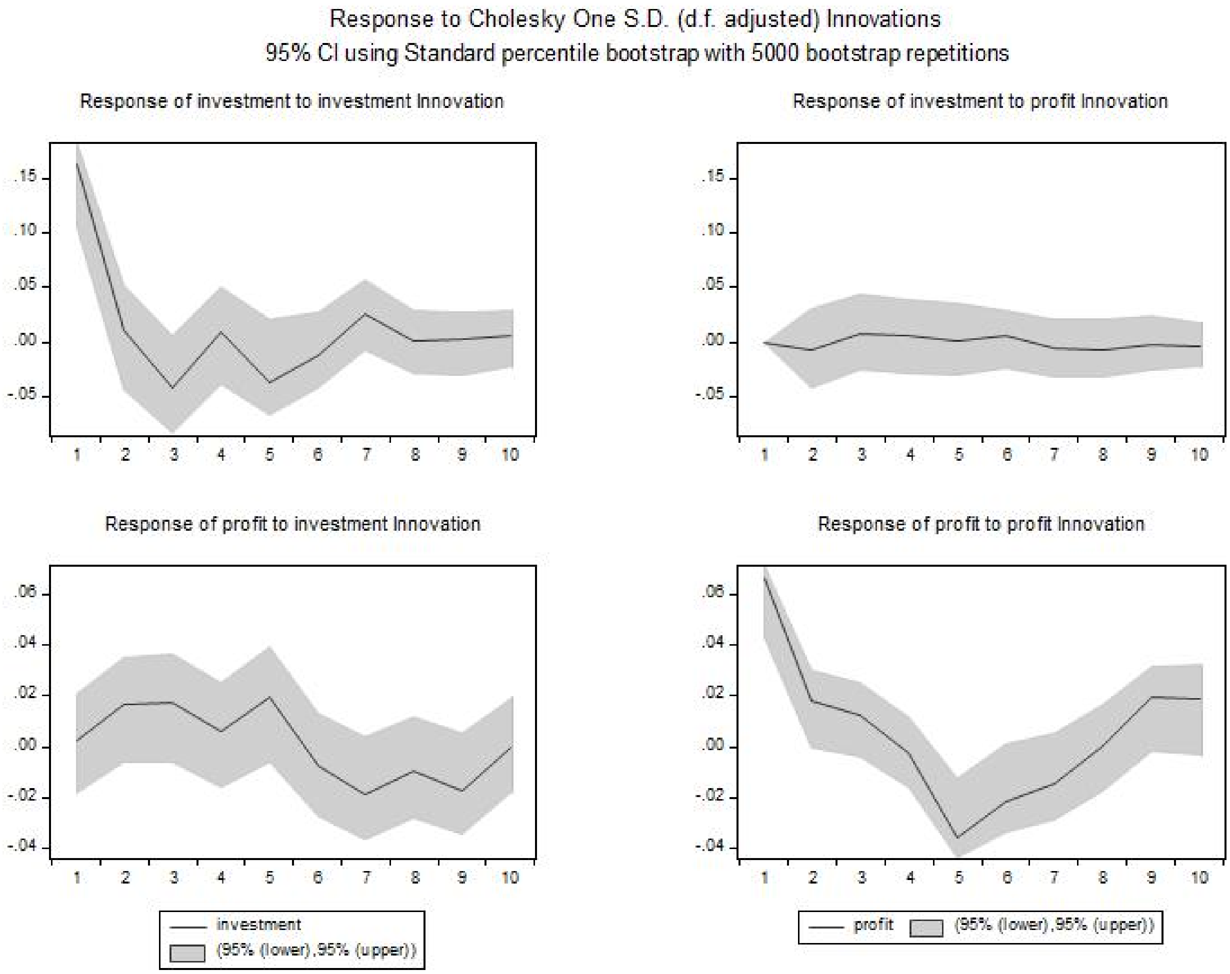
Figure 7: Causality test - full sample



Note: Author computations.

This set of causality tests provides some intriguing results. On the one hand, any increase in unit labour costs implies a symmetric decrease in the profit rate. On the other hand, an increase in the profit rate translates in a positive change in unit labour cost that increase each quarter up to the fifth quarter and then vanishes. It might be seen as a redistribution effect, but it would require a more complete analysis going beyond simple causality tests. It could be interesting to develop a simple structural model including corporate taxes.

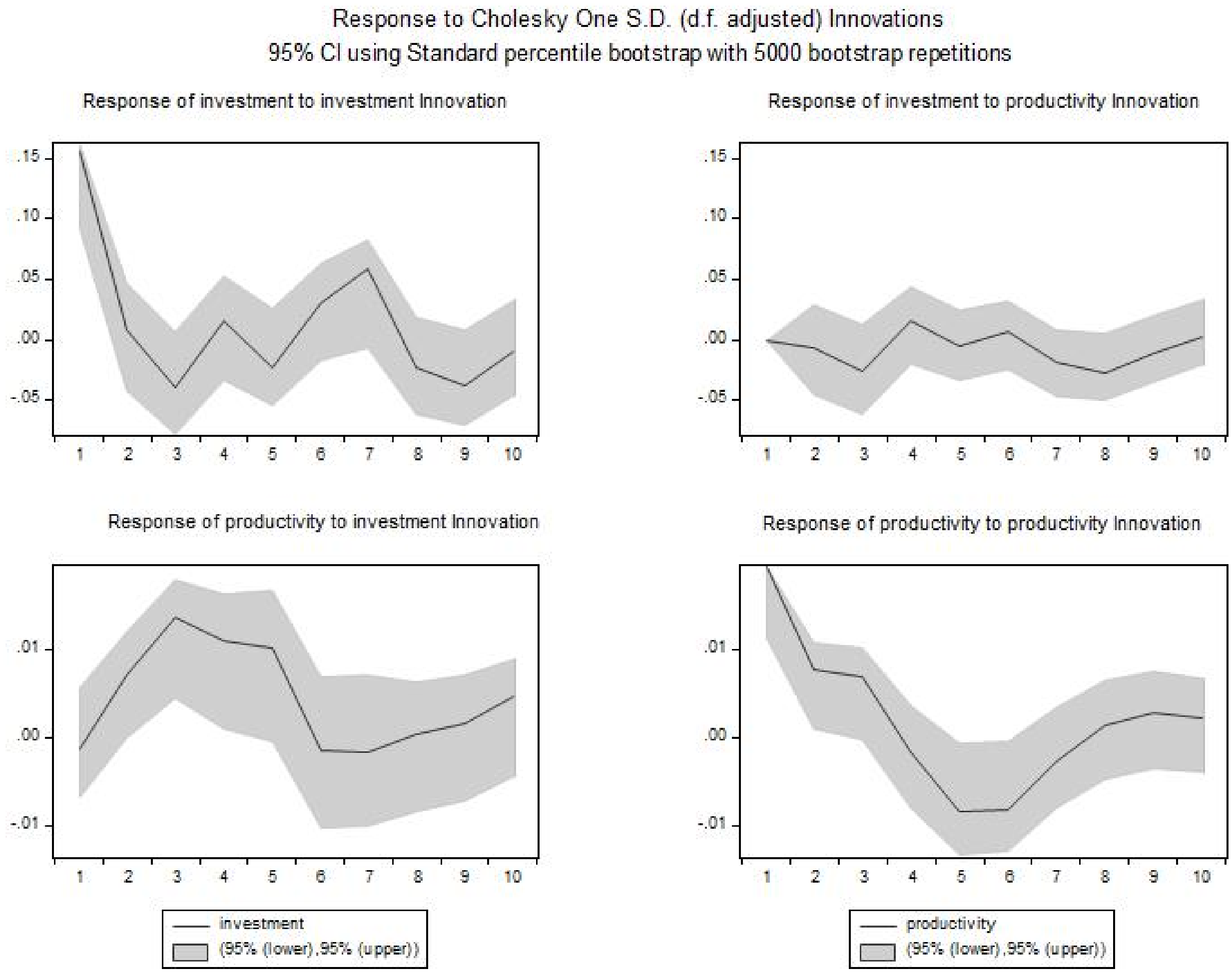
Figure 8: Causality test - up to 2006Q4



Note: Author computations.

As shown by the causality test (table 1) there is no causality over the full sample between changes in investment and changes in profit before the financial crisis (figure 8).

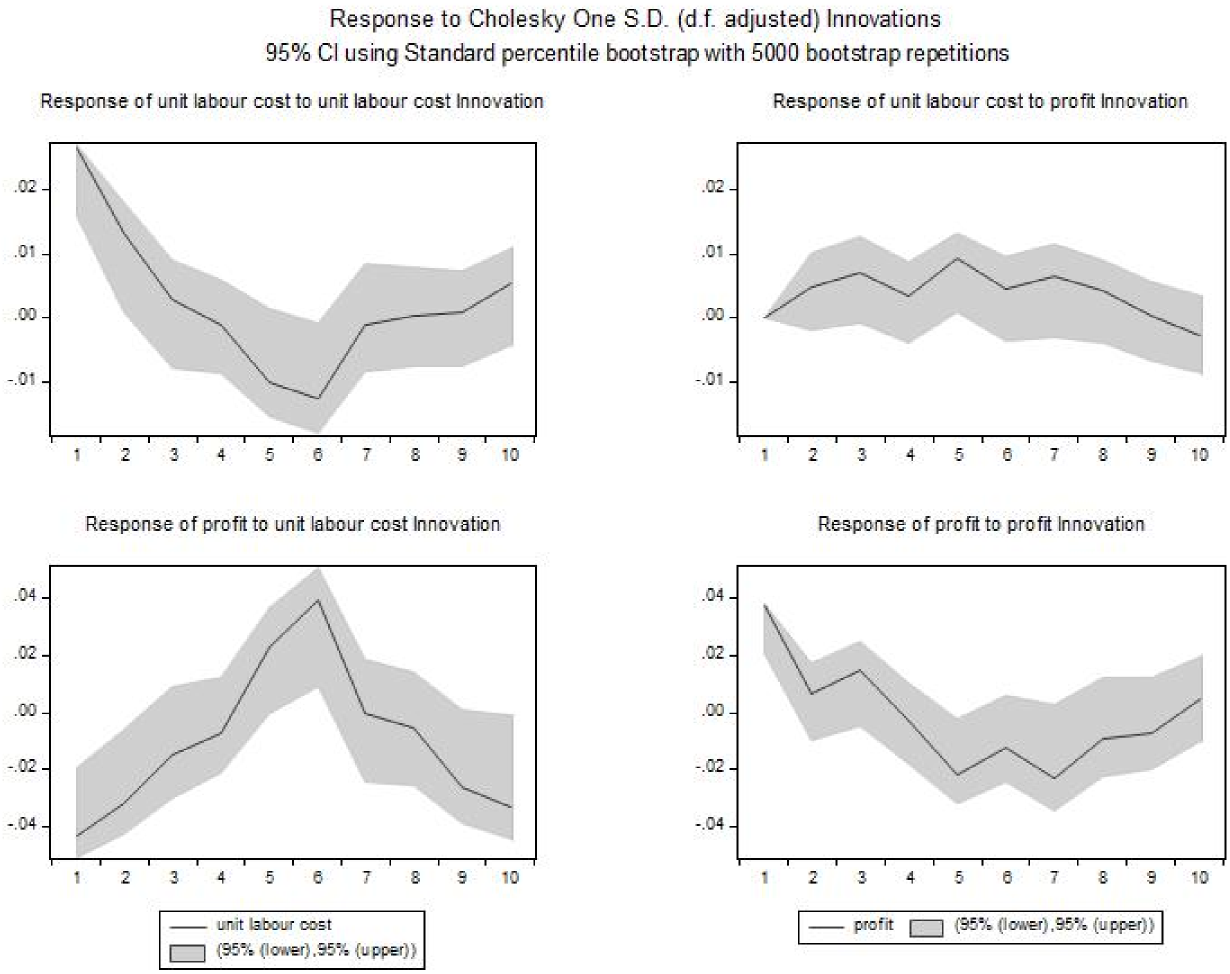
Figure 9: Causality test - up to 2006Q4



Note: Author computations.

These causality tests are in line with the idea of technology transfer (see lower left graph). An increase in the growth rate of investment will increase the productivity of capital during the first year after a shock in investment.

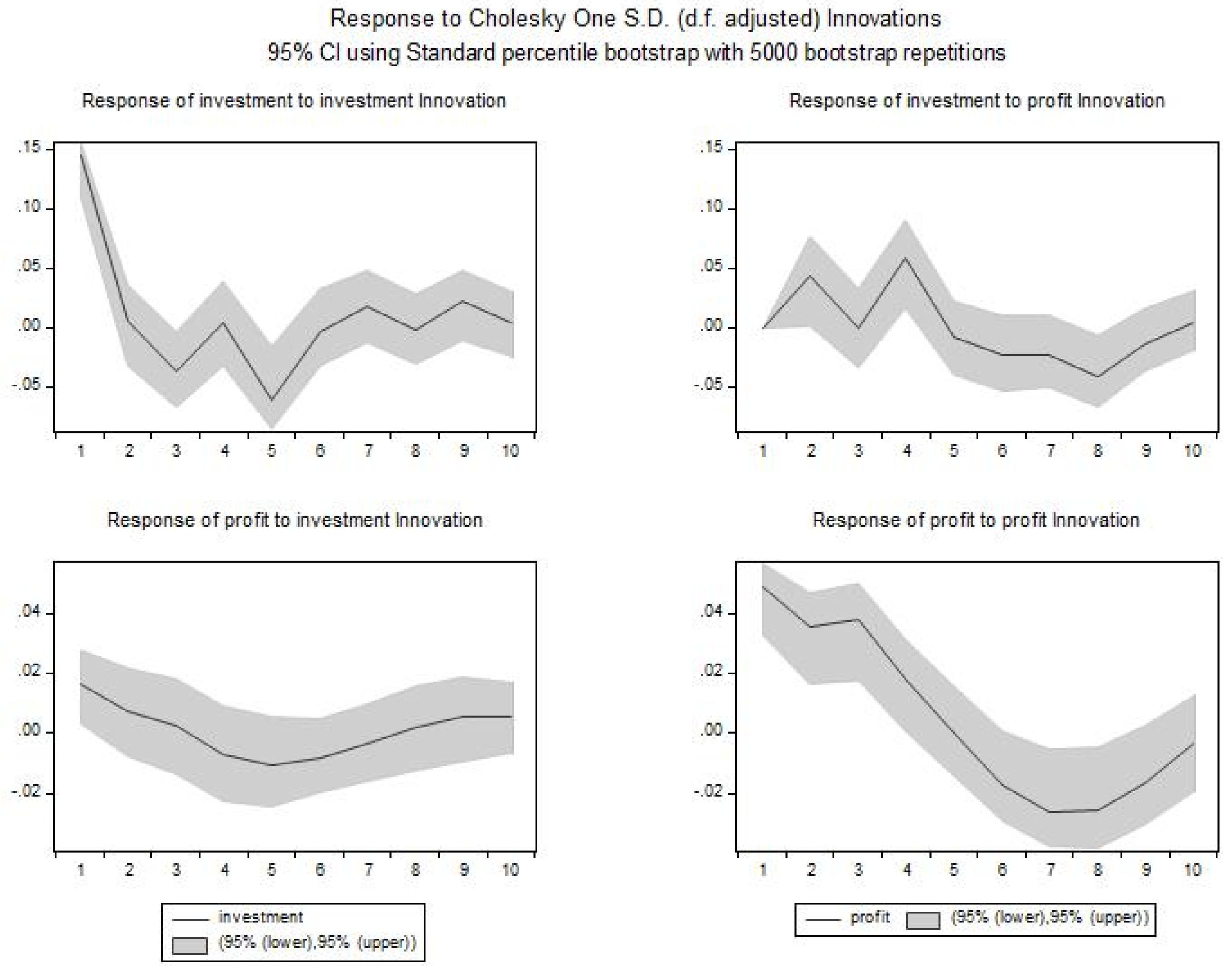
Figure 10: Causality test - up to 2006Q4



Note: Author computations.

These causality tests and impulse response function between unit labour cost and profit are very similar with those pictured in figure 7.

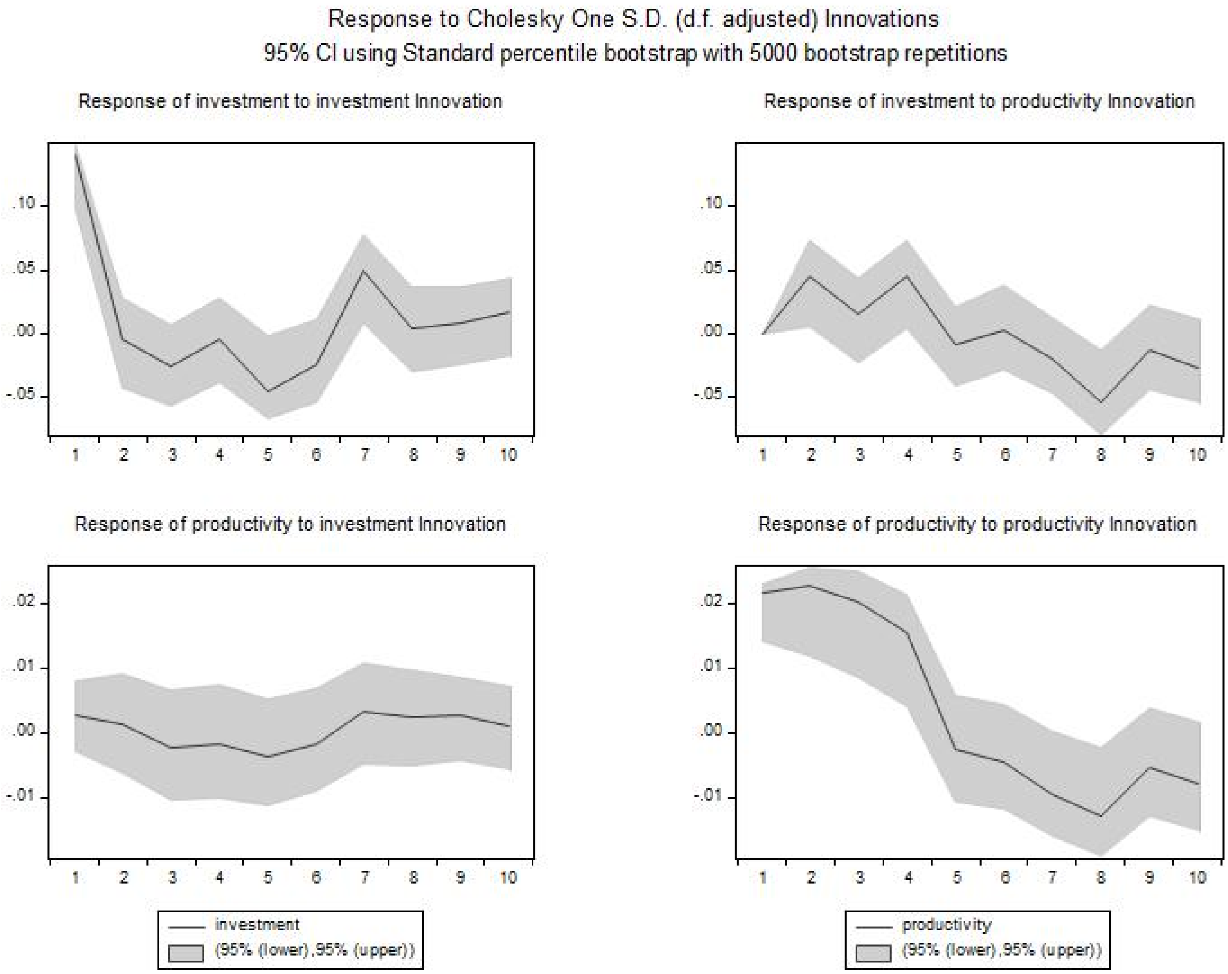
Figure 11: Causality test - from 2009Q1



Note: Author computations.

While before the financial crisis the causality was absent, since the financial crisis an increased rate of profit causes an increase in investment with a lag of four quarters.

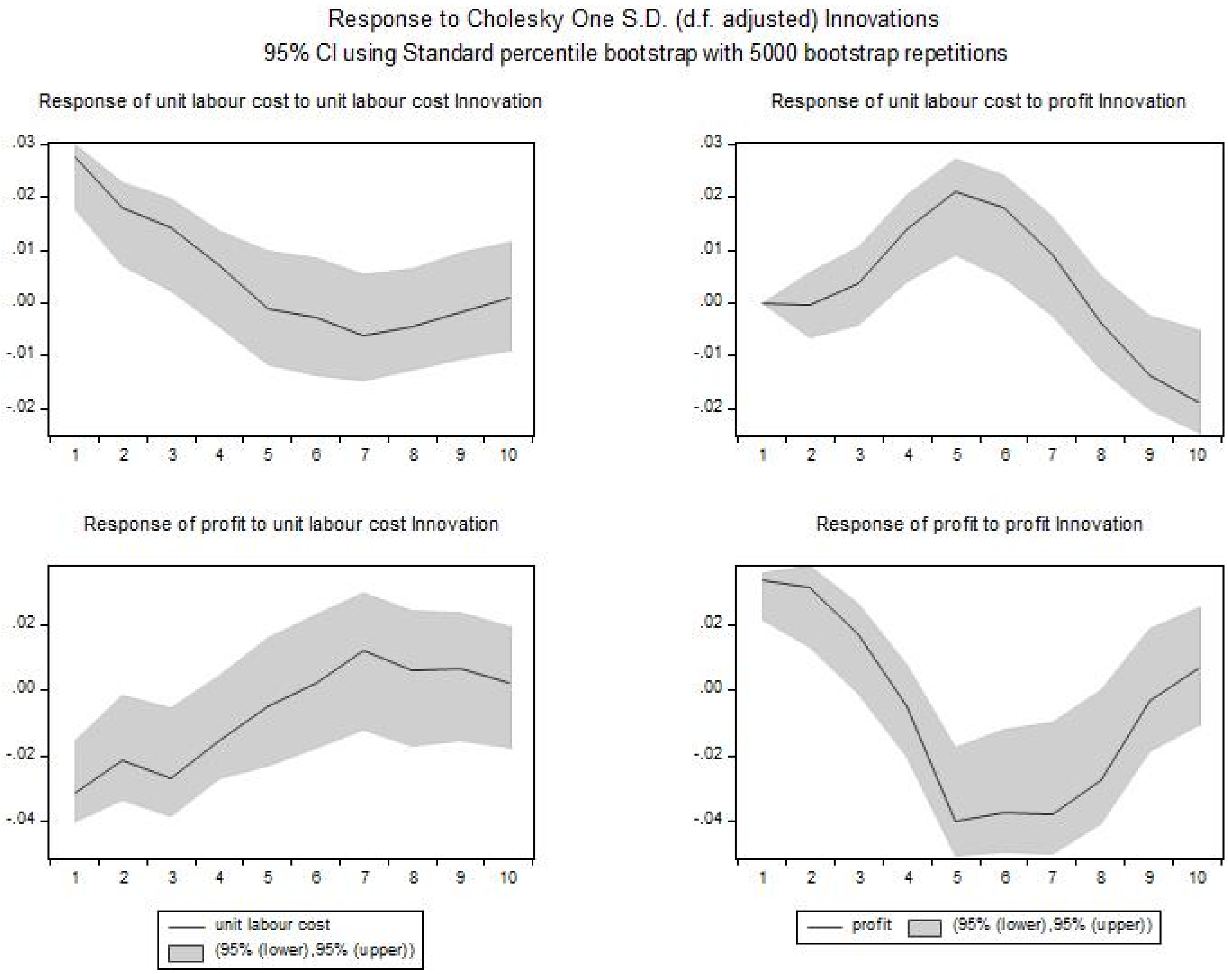
Figure 12: Causality test - from 2009Q1



Note: Author computations.

After the financial crisis impulse response functions show that (upper right graph) that an increase in productivity causes an increase in vestment while it was the converse before the financial crisis (see graph 9).

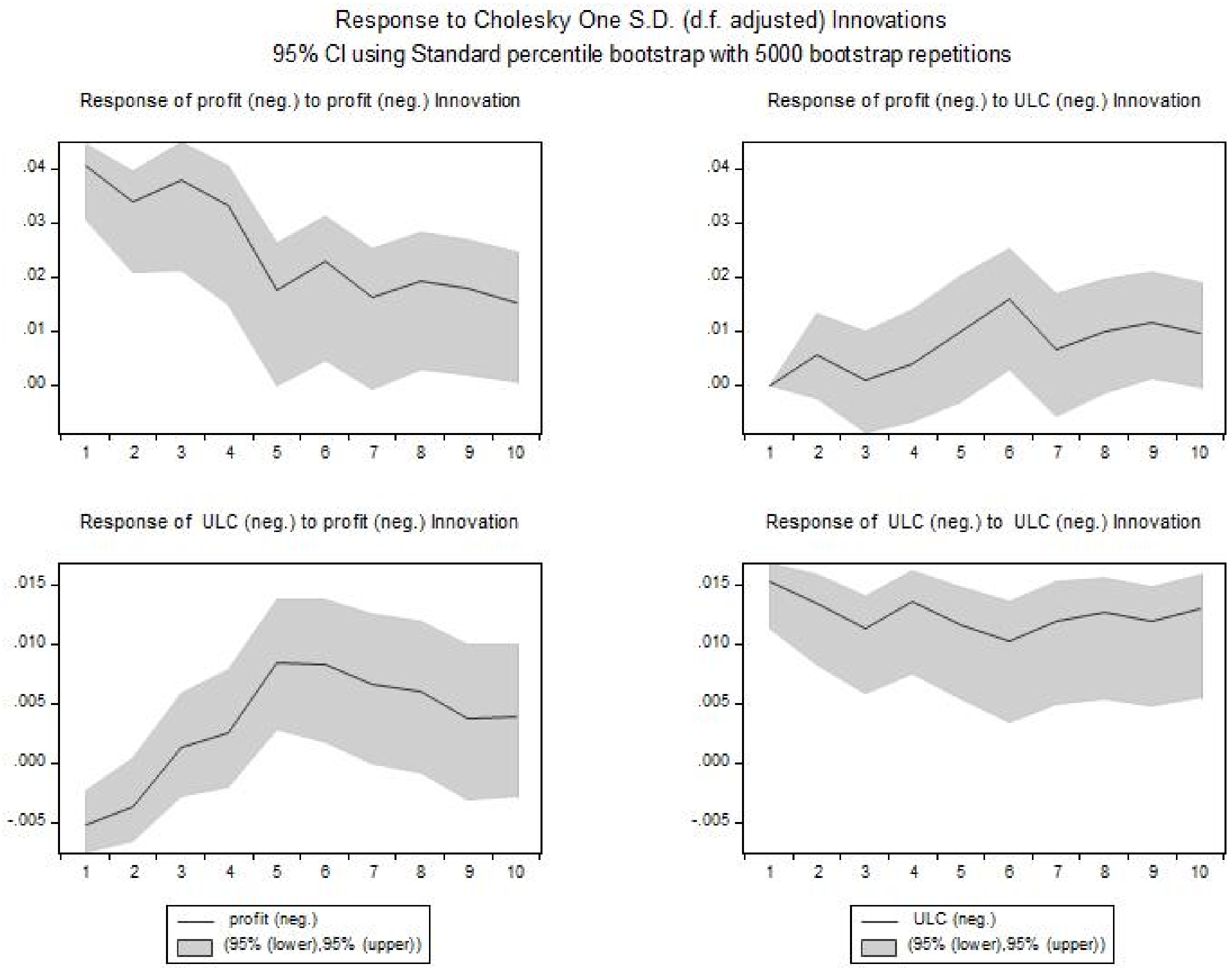
Figure 13: Causality test - from 2009Q1



Note: Author computations.

We find similar results than in figure 7. In particular, the positive causality between profit and unit labour cost. We now turn to asymmetric causality test noting that they mainly concern causality between unit labour cost and profit.

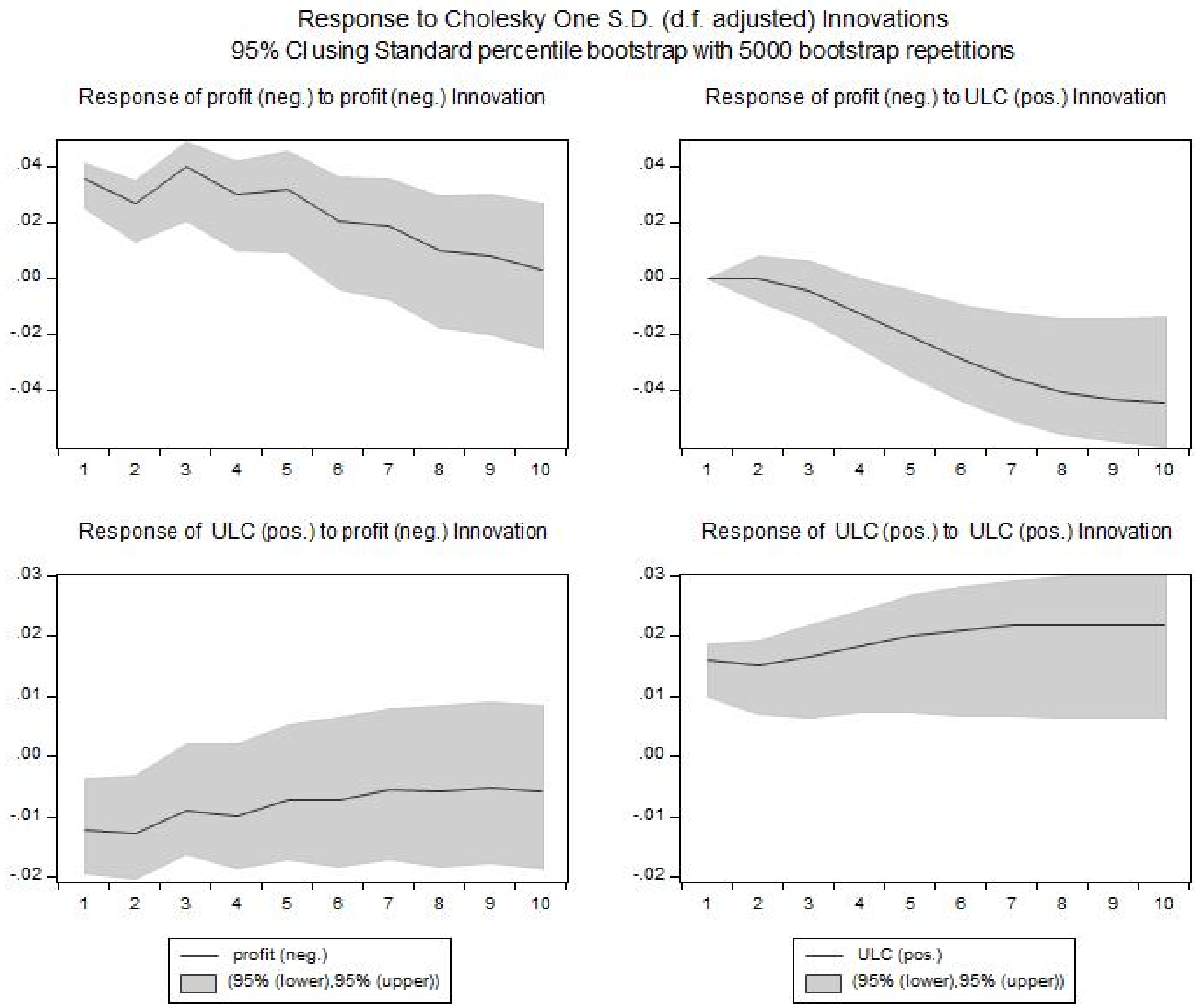
Figure 14: Asymmetric causality test - full sample



Note: Author computations.

According to the lower left graph, a shock on profit first slightly lower unit labour cost (the negative growth becomes more negative) and then after quarter four has a positive effect on negative evolution of unit labour costs.

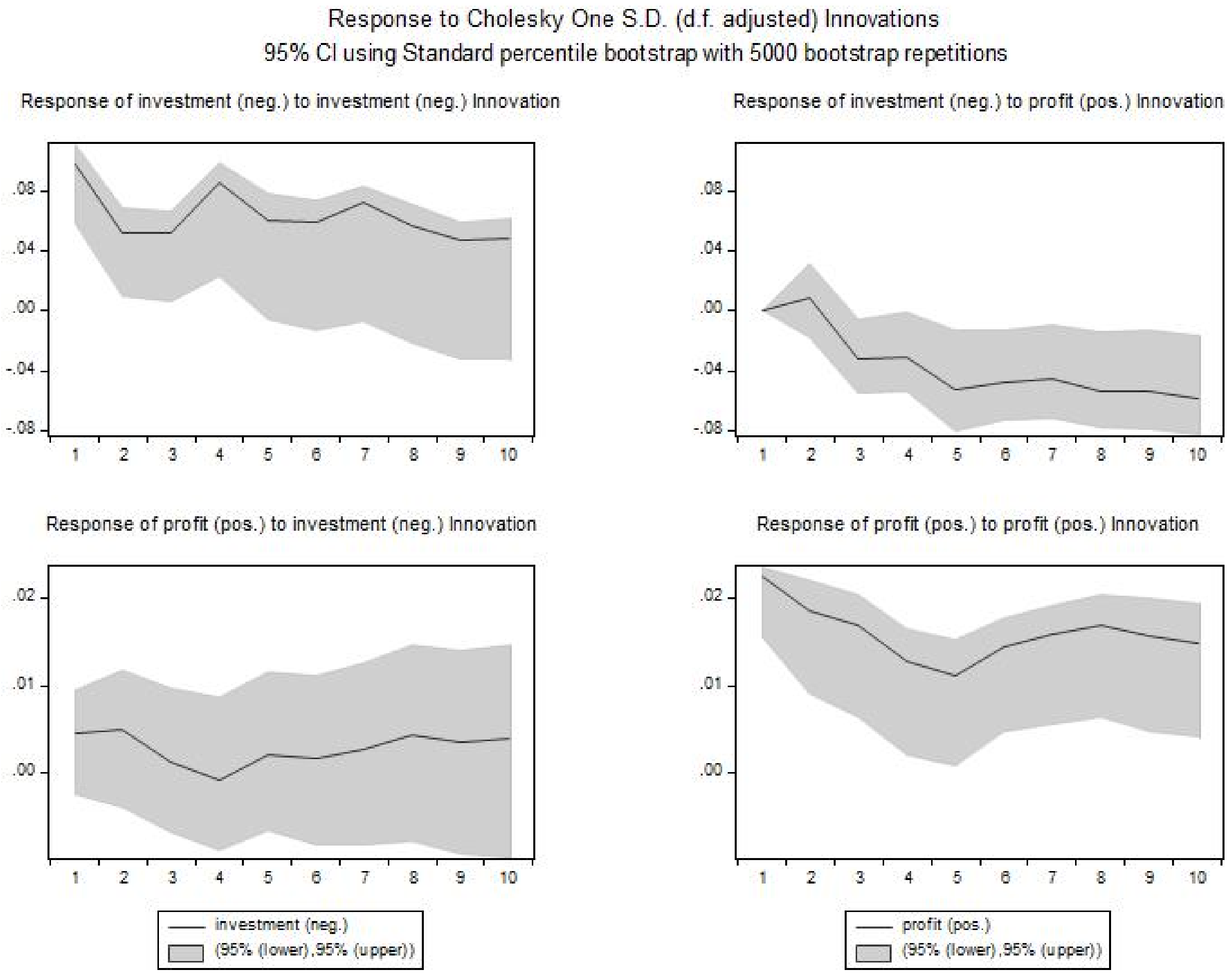
Figure 15: Asymmetric causality test - full sample



Note: Author computations.

In this case (upper right graph), if unit labour cost evolution becomes more positive then negative evolution of the profit becomes more negative. Figures 14 and 15 clearly show that the dynamics of the co-evolution of unit labour cost and profit is complex and certainly asymmetric. What we can propose from the asymmetric causality tests and impulse response functions is that the growing share of labour costs in value added mechanically pressures the capital share and then translate in negative pressures on the rate of profit. This results is in line with the law of the tendency for the rate of profit to fall. Our conclusion is at the opposite of results presented in Manera et al. (2022). According to our results, changes in the labour share play a role in eroding profitability. Alexiou (2022) finds a similar result for the case of United-Kingdom, the negative relationship between the wage share reflecting the strength of labour vis-à-vis capital. This result for Luxembourg might be partly explained by the automatic wage indexation scheme. Interestingly, Orgiazzi (2008), proposes a theoretical framework where the labour share push down the rate of profit and when entrepreneurs are credit constrained leading to financial crisis.

Figure 16: Asymmetric causality test - from 2009Q1



Note: Author computations.

This last asymmetric causality is rather puzzling if the growth rate of profit becomes more positive then negative growth rate of investment becomes more negative. At this stage we provide no explanation for this result.

4 Conclusion

Capital accumulation is pivotal to produce goods and services. Common knowledge is that entrepreneurs invest because of potential profit. However, the various theoretical frameworks as well as empirical studies are not providing unequivocal evidence of direct causality between profit and investment decisions. Using quarterly data from 1995Q1 to 2022Q1 for Luxembourg, we show that the rate of profit of capital fluctuates around 19 percent and reaches a peak in 2007 with a value of 22 percent. Evolution is mainly explained by the evolution of capital productivity rather than the capital share in value added. In addition, capital productivity, and in particular losses seem to be related by low total factor productivity. Causality tests indicate the absence of causality between the rate of profit and investment decision. But, we unearth a causality between the wage share in value added and profit, where the wage share generates negative pressures on profit.

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