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Public and Private Investments: A VAR Analysis of Their Impact on Economic Growth in 18 Advanced Economies

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Abstract: This paper examines the macroeconomic returns on public and private investments in 18 advanced economies from 1965 to 2019, using a Vector Autoregressive (VAR) approach. We assess whether higher investment levels drive economic growth and explore the interplay between public and private investments, particularly regarding crowding-in and crowding-out effects. A sensitivity analysis, altering the order of investments in the VAR model, tests the robustness of the results and highlights the dynamic relationships between them. The findings show that private investment consistently stimulates growth, while public investment's impact varies by country. The analysis underscores the importance of investment sequencing, suggesting the need for flexible policies and a deeper understanding of investment dynamics. This study contributes to the debate on public investment's role in fostering growth and offers empirical insights for future economic policy and investment strategies.

Key-words: Public Investment, Macroeconomic Rates of Return, Crowding-in/out.

JEL: H54, E01, E22, E62.

1 Introduction

Public investment's role in promoting economic growth remains a debated topic, especially during economic downturns. While post-World War II data shows that infrastructure investment contributed to growth in advanced economies, results vary by time and region. This study evaluates the effectiveness of public investment as a tool for economic growth. Public investment, often aimed at stimulating development in underdeveloped areas, also influences private investment. Trends show a decline in the public investment-to-GDP ratio in most advanced economies, with some exceptions in Southern Europe. Meanwhile, private investment exhibits a more diverse trajectory across countries. Historical analysis highlights the potential of public investment to stimulate private investment by improving infrastructure, though it can also lead to crowding-out effects due to higher taxes or borrowing. In recent decades, public investment has increasingly focused on broader goals, such as environmental sustainability, which may yield different economic outcomes compared to earlier periods. The relationship between public and private investment and its effects on economic growth has been widely studied, yet no clear consensus exists. Early research by Buiter (1977) suggested that public investment could complement private investment by providing infrastructure that reduces costs and increases private sector efficiency. Aschauer (1989) further advanced this idea, showing that public infrastructure investment, particularly in the U.S., had a strong positive impact on private sector productivity. However, Aschauer's findings were criticized, with Holtz-Eakin (1993) questioning the robustness of his results and suggesting that public infrastructure had less impact on productivity than claimed. Munnell (1992) supported Aschauer's view but addressed methodological issues, finding that public investments, especially in infrastructure, education, and health, significantly boosted economic growth. Afonso and St. Aubyn (2006, 2009, 2019) analyzed public investment across 17 OECD countries and found mixed effects, with public investment crowding out private investment in some cases while crowding it in others. Similarly, Pereira (2000) found that public investment often boosts private sector performance, while Voss (2000) reported no crowding-in effect in the U.S. and Canada. This study contributes to the ongoing debate by examining public and private investment across 18 advanced economies from 1965 to 2019 using Vector Autoregressive (VAR) models. The results highlight varied impacts of public investment on economic growth, with evidence of crowding-out in some cases and crowding-in in others. These findings emphasize the importance of considering economic context when evaluating the effects of public and private investment. The structure of the paper is organized as follows: Section 2 outlines the methodology, explaining the Vector Autoregressive (VAR) approach used to analyze the dynamic relationships between these investments and to calculate macroeconomic rates of return, and presents the dataset, covering 18 advanced economies from 1965 to 2019. Section 3 discusses the results, examining the interplay between public and private investments and their effects on economic growth. Finally, Section 4 provides conclusions, offering insights for economic policy and directions for future research.

2 Methods and data

In this study, we employ a five-variable Vector Autoregressive (VAR) model to analyze the relationship between public and private investment, output, taxes, and interest rates for each country(add footnote) over the period 1965–2019. The model includes real growth rates of public and private investments, output, taxes, and interest rates, I_{pub}, I_{priv}, Y, Tax, R respectively. The VAR model is expressed as a system of equations where each variable is influenced by its past values and those of the other variables. The VAR model can be written as:

$$X_t = c + \sum_{i=1}^{p} A_i X_{t-i} + \epsilon_t \quad (1)$$

where X_t denotes the (5 x 1) vector of the five endogenous variables given by:

$$X_t = \begin{bmatrix} \Delta \log I_{pub,t} & \Delta \log I_{priv,t} & \Delta \log Y_t & \Delta \log Tax_t & \Delta R_t \end{bmatrix}'$$

c is a (5×1) vector of intercept terms, A_i is the matrix of autoregressive coefficients of order i, and the vector of random disturbances $\epsilon_t \equiv \begin{bmatrix} \epsilon_{I_{pub},t} & \epsilon_{I_{priv},t} & \epsilon_{Y,t} & \epsilon_{Tax,t} & \epsilon_{R,t} \end{bmatrix}'$ contains the reduced form OLS residuals. The lag lengths, p, will be determined by the usual information criteria.

By imposing a set of restrictions, it is possible to identify orthogonal shocks, η, for each of the variables in (1). To compute these orthogonal innovations via the random disturbances:

$$\eta_t = B\epsilon_t \quad (2)$$

The estimation of (1) allows $Cov(\epsilon)$ to be determined. Therefore, with the orthogonal restrictions and by means of adequate normalization we have $Cov(\eta) = I$, where I is a (5×5) identity matrix, and we can write:

$$Cov(\eta_t) = Cov(B\epsilon_t) = BCov(\epsilon_t)B' \quad (3)$$

$$I = BCov(\epsilon_t)B' \quad (4)$$

Since B is a square (5×5) matrix, which in our case has a dimension of five, B then has 25 parameters that need to be identified. By imposing orthogonality from (4), only 15 parameters can be determined, essentially from the five variances and from the 10 covariances. For the complete identification of the model, we need 10 more restrictions. Using a Cholesky decomposition, we impose restrictions to identify orthogonal

shocks, ensuring that public investment impacts all variables immediately, while private investment and other variables respond with lags.

We can then impose a lower triangular structure to B^{-1},

$$B^{-1} = D = \begin{bmatrix} d_{11} & 0 & 0 & 0 & 0 \\ d_{21} & d_{22} & 0 & 0 & 0 \\ d_{31} & d_{32} & d_{33} & 0 & 0 \\ d_{41} & d_{42} & d_{43} & d_{44} & 0 \\ d_{51} & d_{52} & d_{53} & d_{54} & d_{55} \end{bmatrix} \quad (5)$$

where the d_{ij} are the elements of D.

Once the VAR model is estimated, we calculate impulse response functions (IRFs) to measure how each variable reacts to shocks in the system. Specifically, we compute four key rates of return: (i) the partial rate of return for public investment, (ii) the rate of return for total investment driven by public investment, (iii) the partial rate of return for private investment, and (iv) the rate of return for total investment driven by private investment. To do this, we first calculate the elasticities of output relative to public and private investment, and then use these to derive the long-term marginal productivity of both types of investment. Finally, using an assumed average life of 20 years for capital goods, we determine the partial and total rates of return for both public and private investments.

The first step is to compute the long-run elasticities of output with respect to public and private investment, respectively. That is, the elasticity of output is calculated from the change of output by the change of public investment and private investment:

$$\epsilon_{I_{pub}} = \frac{\Delta \log Y}{\Delta \log I_{pub}} \quad (7)$$

$$\epsilon_{I_{priv}} = \frac{\Delta \log Y}{\Delta \log I_{priv}} \quad (8)$$

The elasticities of both public and private investments are obtained from the VAR estimation for each country. That is, innovations to both types of investments allow us to compute these elasticities. Once we obtain $\epsilon_{I_{pub}}$ and $\epsilon_{I_{priv}}$, we can compute the long-term marginal productivity of public and private investments by:

$$MPI_{pub} = \frac{\Delta Y}{\Delta I_{pub}} = \epsilon_{I_{pub}} \frac{Y}{I_{pub}} \quad (9)$$

$$MPI_{priv} = \frac{\Delta Y}{\Delta I_{priv}} = \epsilon_{I_{priv}} \frac{Y}{I_{priv}} \quad (10)$$

After we compute the long-term marginal productivity of public and private investments, we can obtain the marginal productivity of total investment with respect to each type of investment's innovation:

$$MPTI = \frac{\Delta Y}{\Delta I_{pub} + \Delta I_{priv}} = \frac{1}{MPI_{pub}^{-1} + MPI_{priv}^{-1}} \quad (11)$$

As we compute the above-mentioned equations, the final step is to calculate the four rates of returns in the following manner:

From equation 9, the partial rate of return of public investment, r_1 is:

$$(1 + r_1)^{20} = MPI_{pub} \quad (12)$$

And from equation 11, the rate of total return of investment, r_2 is:

$$(1 + r_2)^{20} = MPTI \quad (13)$$

Equations 10 and 11 allow us to compute both the partial rate of return of private investment and the rate of total investment return, r_3 and r_4 respectively:

$$(1 + r_3)^{20} = MPI_{priv} \quad (14)$$

$$(1 + r_4)^{20} = MPTI \quad (15)$$

We use annual data from 18 advanced economies, mostly EU member states, spanning 1965–2019. The countries included are listed in table 1, with Austria, Finland, France, Germany, the United Kingdom, and the United States having data from 1965, while others, like Greece, Luxembourg, and Norway, begin in later years.

Table 1: Public and Private Investment-to-GDP ratios

Country	**Public Investment-to-GDP (%)**			**Private Investment-to-GDP (%)**		
	1980-1999	**2000-2019**	**80-2019**	**1980-1999**	**2000-2019**	**80-2019**
AUT	4.0	2.9	3.5	20.8	20.4	20.6
BEL	2.8	2.3	2.5	17.7	20.2	18.9
DNK	2.4	3.1	2.7	14.1	16.9	15.5
FIN	4.2	3.8	4.0	19.9	18.7	19.3
FRA	4.2	3.9	4.1	17.2	18.4	17.8
DEU	2.5	2.2	2.3	17.5	17.9	17.7
GRC	2.9	4.0	3.4	14.6	12.2	13.4
IRL	3.2	2.9	3.1	17.8	21.6	19.7
ITA	3.4	2.8	3.1	17.2	16.7	17.0
JPN	5.6	4.2	4.9	24.4	20.3	22.4
LUX	3.2_a	4.0	3.7_a	14.3_a	13.7	13.9_a
NLD	3.5	3.7	3.6	15.9	16.5	16.2
NOR	3.9	4.4	4.2	18.1	18.5	18.3
PRT	3.3	3.1	3.2	17.3	16.3	16.8
ESP	3.6	3.2	3.4	15.5	18.1	16.8
SWE	4.8	4.3	4.5	17.4	18.7	18.0
GBR	2.4	2.5	2.4	16.7	14.7	15.7

Source: European Commission AMECO database, 2019.
Notes: a 1990.

The variables in the VAR model include public and private investment, GDP, taxes, and interest rates. Public and private investments are measured through general government and private sector gross fixed capital formation at current prices, respectively. GDP and taxes (aggregated from direct taxes, indirect taxes, and social contributions) are also in current prices. To adjust for inflation, we converted GDP, public and private investments, and taxes into real terms using the GDP and gross fixed capital formation price deflators, with 2015 as the base year. Real interest rates were derived from nominal long-term interest rates adjusted for inflation, using the consumer price index. Tax data was sourced from the OECD, while other series come from the European Commission's AMECO database.

Table 2

Unit Root Tests, Variables in First Differences: Augmented Dickey–Fuller Test Statistics

Country	Δ log Y		Δ log Ipub		Δ log Ipriv		Δ log Tax		Δ R	
	t-statistics	Critical value	t-statistics	Critical value	t-statistics	Critical value	t-statistics	Critical value	t-statistics	Critical value
Austria	-6.12	-4.14	-6.16	-4.14	-6.63	-4.14	-5.90	-4.14	-6.21	-4.14
Belgium	-6.88	-4.16	-6.48	-4.16	-5.21	-4.16	-5.01	-4.16	-7.02	-4.16
Denmark	-5.59	-4.17	-7.05	-4.17	-5.11	-4.17	-5.64	-4.18	-8.61	-4.17
Finland	-4.84	-4.14	-8.38	-4.14	-4.97	-4.14	-5.54	-4.14	-6.63	-4.14
France	-5.14	-4.14	-5.08	-4.14	-4.48	-4.14	-6.69	-4.14	-8.00	-4.14
Germany	-6.09	-4.14	-5.55	-4.14	-5.26	-4.14	-5.20	-4.14	-6.26	-4.15
Greece	-1.65***	-1.61*	-4.88	-4.36	-2.49***	-1.95*	-2.27**	-1.95	-4.53	-4.36
Ireland	-4.74	-4.17	-3.87	-3.51	-1.63***	-1.61*	-4.30	-4.17	-6.27	-4.17
Italy	-6.57	-4.16	-6.68	-4.16	-5.08	-4.16	-7.60	-4.16	-6.58	-4.16
Japan	-6.20	-4.17	-5.11	-4.17	-4.42	-4.18	-2.66	-2.62*	-7.95	-4.17
Luxembourg	-4.52	-4.32	-6.20	-4.32	-6.96	-4.32	-5.25	-4.32	-6.50	-4.32
Netherlands	-4.27	-4.16	-6.16	-4.16	-4.75	-4.18	-5.04	-4.16	-8.20	-4.16
Norway	-3.28***	-3.21	-4.00	-3.57	-3.71**	-3.56	-3.93**	-3.55	-10.80	-4.26
Portugal	-2.00**	-1.95*	-5.42	-4.26	-2.75	-2.64*	-6.75	-4.26	-6.90	-4.26
Spain	-1.67***	-1.61*	-5.22	-4.21	-3.00	-2.62*	-4.02**	-3.53	-12.30	-4.21
Sweden	-5.37	-4.16	-8.05	-4.16	-4.71	-4.16	-5.38	-4.19	-10.17	-4.16
United Kingdom	-5.14	-4.14	-8.54	-4.14	-5.49	-4.14	-4.92	-4.14	-2.60**	-1.95*
United States	-5.85	-4.14	-3.56**	-3.50	-5.12	-4.15	-6.08	-4.14	-6.37	-4.14

Notes: Y – GDP, Ipub – public investment, Ipriv – private investment, Tax – total taxes, and R – real interest rates.
Critical values are for the one percent level, where we included constant and trend in testing for a unit root, unless otherwise mentioned.

Subscripts: * indicates the test is made without constant nor trend, ** and *** indicate stationarity at the 5% and 10% levels, respectively.

3 Results

3.1 Building the VAR Model

We estimate a five-variable VAR model for each country, ordering the variables as public investment, private investment, GDP, taxes, and interest rate. All variables, except the interest rate, are in real terms and expressed as logarithmic growth rates. Diagnostic tests indicate that most variables are non-stationary in levels, so we use first differences, making them stationary (I(0)). Unit root test results are reported in table 2.

The Akaike and Schwarz information criteria suggest using one lag for all countries to avoid losing degrees of freedom. Diagnostic tests (table 3) show that most countries exhibit no serial correlation in residuals, except Japan and the U.S. Additionally, most countries report normal residuals, though four countries show non-normality. The heteroscedasticity results are mixed.

Table 3

	Diagnostic tests			
Country	**Autocorrelation test (p value)**[a]	**Normality test (p value)**[b]	**Heteroscedasticity (p value)**[c]	**Number of observations**
Austria	0.429	0.000	0.321	53
Belgium	0.586	0.249	0.003	47
Denmark	0.981	0.970	0.009	47
Finland	0.675	0.011	0.219	53
France	0.279	0.000	0.012	53
Germany	0.129	0.000	0.004	53
Greece	0.071	0.866	0.421	26
Ireland	0.100	0.000	0.003	47
Italy	0.793	0.000	0.054	48
Japan	0.003	0.000	0.000	46
Luxembourg	0.583	0.003	0.168	28
Netherlands	0.066	0.000	0.292	48
Norway	0.669	0.860	0.980	33
Portugal	0.148	0.001	0.027	33
Spain	0.187	0.000	0.027	40
Sweden	0.683	0.535	0.094	48
United Kingdom	0.101	0.000	0.008	53
United States	0.020	0.006	0.018	53

Notes:
[a] Multivariate residual serial correlation Lagrange multiplier test. For the null hypothesis of no serial autocorrelation (of order 1) the test statistic has an asymptotic chi-squared distribution with k^2 degrees of freedom.

We also account for the 2008 financial crisis with a dummy variable for 2008–2019, which is statistically significant across all countries. For Germany, we include a 1991 dummy to control for the structural break caused by reunification.

3.2 The Macroeconomic Rates of Returns

The VAR models allow for the calculation of Impulse Response Functions (IRFs), illustrating GDP's response to shocks in public and private investment. Figure 1 shows responses for Portugal, the United Kingdom, and Spain, with further country results in Appendix 1.

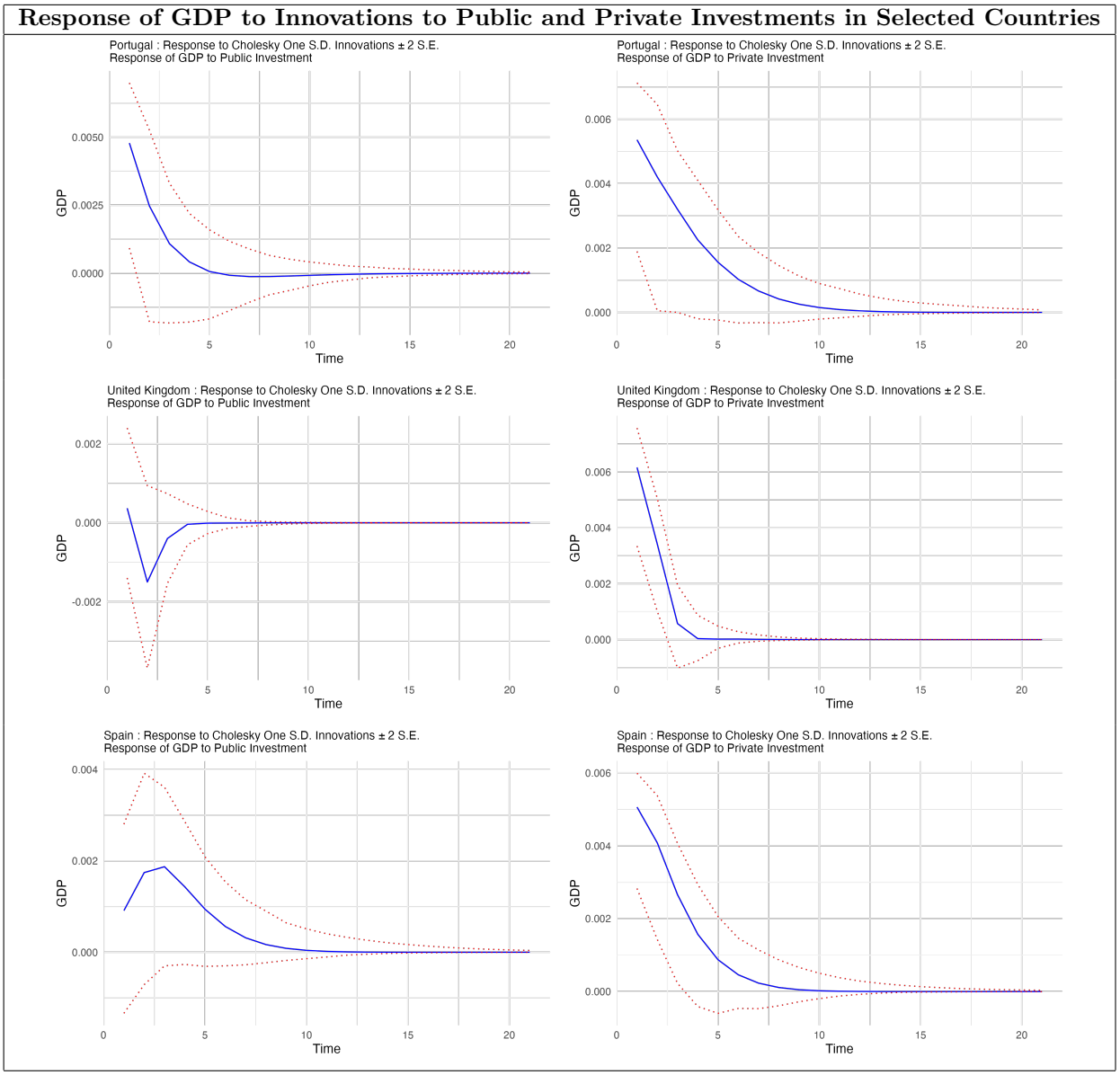


Figure 2: Impulse Response Functions in Selected Countries: Portugal, the United Kingdom, and Spain.

Portugal's GDP reacts quickly and positively to both public and private investment shocks, though public investment's effects are more volatile and short-lived. In the U.K., the response is slower and more subdued, while in Spain, public investment shocks generate significant but short-lived GDP increases. Using the IRFs, we compute macroeconomic rates of return for public and private investments. table 4 (Panel A) reveals that

public investment has a mixed impact, with only 10 out of 18 countries showing positive output elasticity. The average output elasticity for public investment is 0.046, with France exhibiting the highest elasticity (0.26), while Norway shows a negative elasticity (-0.21). Marginal productivity of public investment (MPIpub) also varies significantly, averaging 1.42 across countries. Germany shows the highest MPIpub (6.09), while Norway reports the lowest (-5.16). Public investments yield an average total rate of return of 1.9%, with the U.K. showing a high return (11.8%) and Denmark a negative return (-11.09%).

Table 4

Long-run elasticities, marginal productivity and rates of return (1965–2019)

a) Impulse on public investment

country	Output elasticity	MPIpub	Partial rate of return (%)	MPTIpub	Total rate of return (%)
Austria	0.02	0.62	-2.38	1.34	1.48
Belgium	-0.05	-1.73	NA	0.71	-1.69
Denmark	0.00	0.13	-9.60	0.10	-11.09
Finland	0.01	0.36	-5.02	0.31	-5.66
France	0.26	6.39	9.72	3.75	6.83
Germany	0.16	6.09	9.45	1.61	2.40
Greece	0.26	7.21	10.38	2.41	4.49
Ireland	0.08	2.77	5.23	3.85	6.97
Italy	0.06	1.99	3.51	2.29	4.22
Japan	0.13	2.67	5.03	1.64	2.52
Luxembourg	-0.01	-0.16	NA	-0.60	NA
Netherlands	0.01	0.23	-7.03	0.37	-4.82
Norway	-0.21	-5.16	NA	2.30	4.26
Portugal	0.09	3.14	5.88	1.95	3.40
Spain	0.08	2.72	5.12	1.97	3.44
Sweden	-0.05	-1.00	NA	-1.43	NA
United Kingdom	-0.03	-1.05	NA	9.30	11.80
United States	0.01	0.36	-5.02	-0.30	NA

b) Impulse on private investment

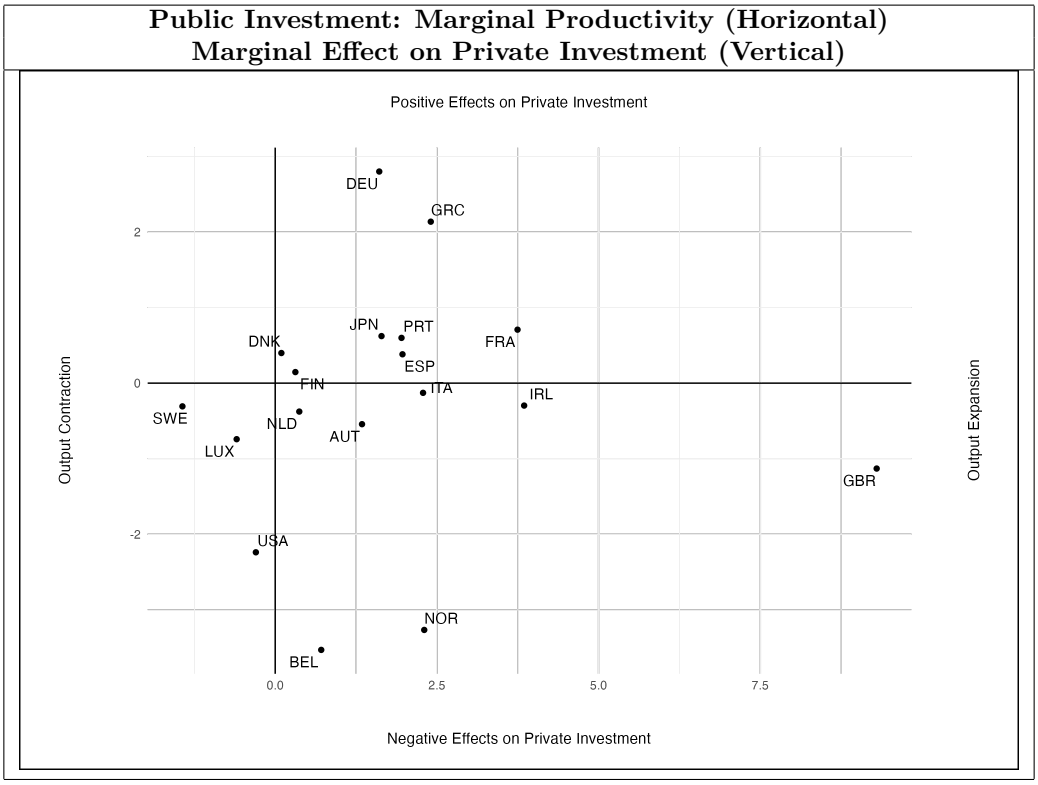
country	Output elastisity	MPIpub	Partial rate of return (%)	MPTIpub	Total rate of return (%)
Austria	0.27	1.31	1.35	1.25	1.10
Belgium	0.13	0.72	-1.64	0.74	-1.49
Denmark	0.17	1.14	0.67	1.11	0.53
Finland	0.27	1.34	1.47	1.31	1.37
France	0.36	1.97	3.45	1.82	3.03
Germany	0.43	2.44	4.57	2.35	4.36
Greece	0.25	2.14	3.87	1.99	3.51
Ireland	0.17	0.90	-0.52	0.85	-0.81
Italy	0.35	1.97	3.44	1.71	2.71
Japan	0.27	1.17	0.81	1.17	0.77
Luxembourg	0.30	2.15	3.91	2.21	4.04
Netherlands	0.21	1.31	1.37	1.27	1.18
Norway	0.07	0.40	-4.52	0.38	-4.75
Portugal	0.30	1.80	2.97	1.63	2.48
Spain	0.28	1.73	2.78	1.61	2.40
Sweden	0.18	1.02	0.09	1.04	0.18
United Kingdom	0.31	2.03	3.60	1.89	3.24
United States	0.30	2.06	3.68	1.99	3.51

NA – not available. The rate of return cannot be computed in this case since the marginal productivity is negative.

MPIpub – marginal productivity of public investment. MPIpriv – marginal productivity of private investment. MPTI – marginal productivity of total investment. We use the average of the GDP-to-investment ratios for the period 1960–2014 (or starting later, depending on data availability, see notably the sample sizes mentioned before).

For private investment, Panel B shows consistently positive impacts on GDP, with an average elasticity of 0.257. Germany has the highest output elasticity (0.43). The marginal productivity of private investment (MPIpriv) averages 1.53, with Germany again leading at 2.44. The average total rate of return for private investments is 1.52%, with the U.S. at 3.51% and Norway at -4.75%. These findings align with Afonso & St. Aubyn (2019), suggesting variability in the rates of return, especially for public investments. ## Crowding-in and Crowding-out Effects

The VAR model also captures the marginal effects of public investment on private investment. Figure 3 shows that public investment leads to crowding-in effects in Denmark, France, Germany, Greece, and others, enhancing private investment. In contrast, countries like Belgium and Sweden exhibit crowding-out effects, where public investment competes with the private sector for resources.



Note: Austria, AUT; Belgium, BEL; Denmark, DNK; Finland, FIN; France, FRA; Germany, DEU; Greece, GRC; Ireland, IRL; Italy, ITA; Japan, JPN; Luxembourg, LUX; Netherlands, NLD; Norway, NOR; Portugal, PRT; Spain, ESP; Sweden, SWE; United Kingdom, GBR; United States, USA.

Figure 3: Public Investment: Marginal Productivity (Horizontal) and Marginal Effect on Private Investment (Vertical)

Private investment also influences public investment. As figure 4 illustrates, private investments crowd in public investment in countries like Luxembourg and Denmark. However, countries such as the U.S. and Austria show crowding-out effects, where private investment displaces public investment.

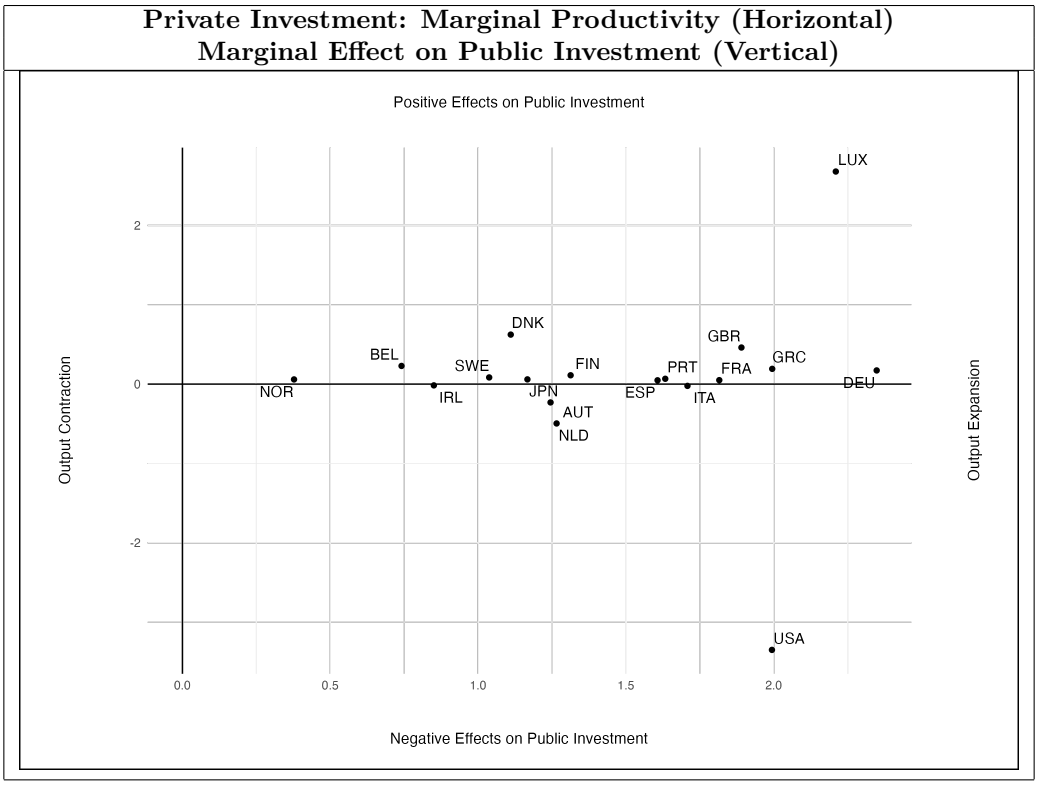


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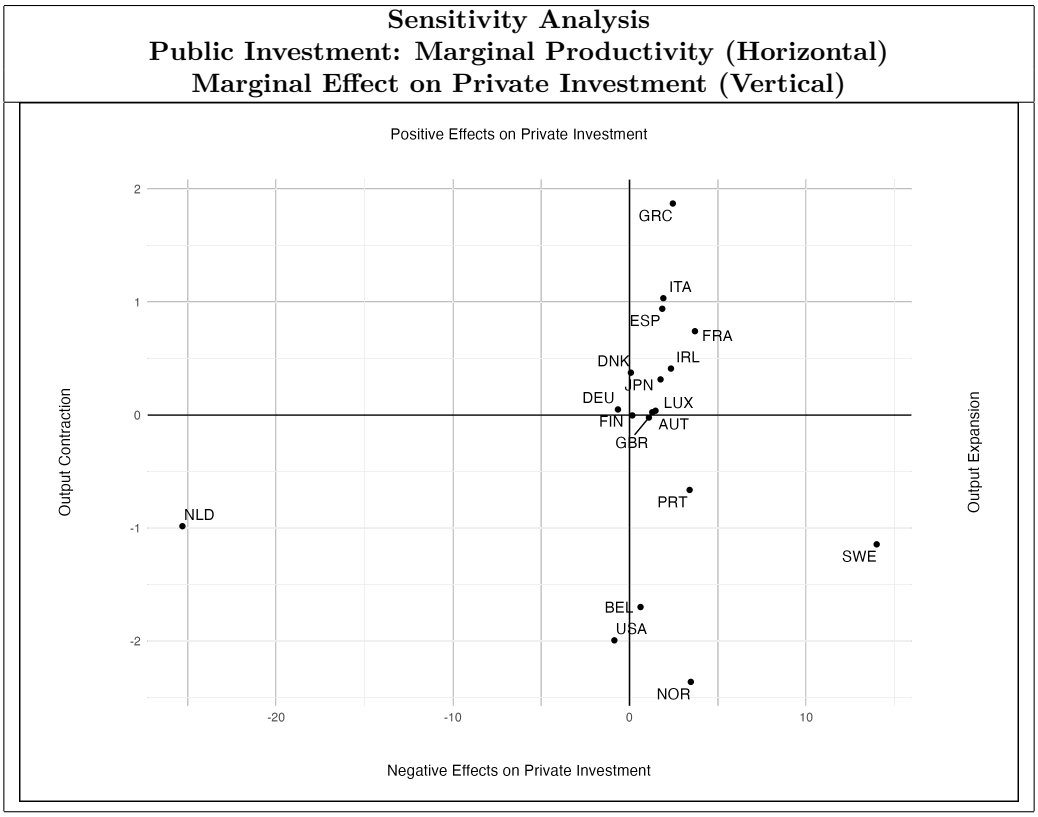
Figure 4: Private Investment: Marginal Productivity (Horizontal) and Marginal Effect on Public Investment (Vertical)

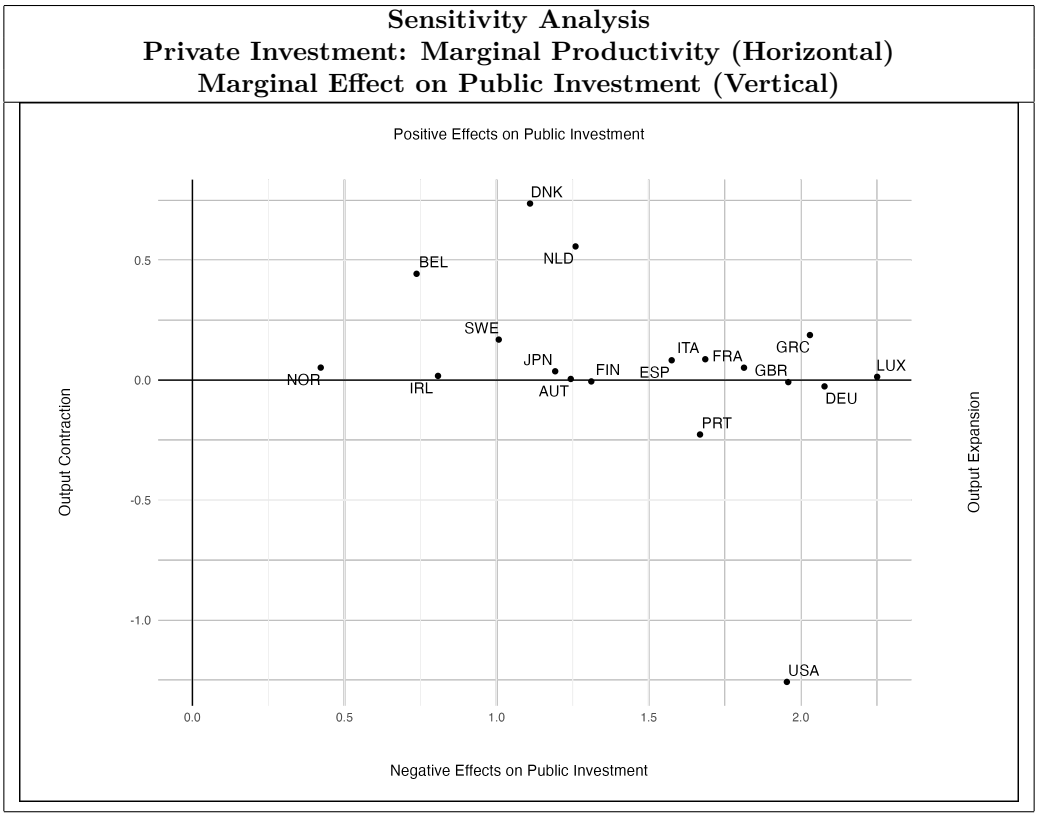
3.3 Sensitivity Analysis

To test robustness, we reordered the VAR model, placing private investment before public investment. This reordering significantly altered the results for some countries (figures 5 and 6). For instance, Germany and the Netherlands showed reduced public investment productivity, while Sweden and Norway exhibited increases. These findings emphasize the importance of sequencing in modeling economic relationships.



Note: Austria, AUT; Belgium, BEL; Denmark, DNK; Finland, FIN; France, FRA; Germany, DEU; Greece, GRC; Ireland, IRL; Italy, ITA; Japan, JPN; Luxembourg, LUX; Netherlands, NLD; Norway, NOR; Portugal, PRT; Spain, ESP; Sweden, SWE; United Kingdom, GBR; United States, USA.

Figure 5: Public Investment: Marginal Productivity (Horizontal) and Marginal Effect on Private Investment (Vertical)



Note: Austria, AUT; Belgium, BEL; Denmark, DNK; Finland, FIN; France, FRA; Germany, DEU; Greece, GRC; Ireland, IRL; Italy, ITA; Japan, JPN; Luxembourg, LUX; Netherlands, NLD; Norway, NOR; Portugal, PRT; Spain, ESP; Sweden, SWE; United Kingdom, GBR; United States, USA.

Figure 6: Private Investment: Marginal Productivity (Horizontal) and Marginal Effect on Public Investment (Vertical)

In conclusion, the results highlight the nuanced relationship between public and private investments, with varying crowding effects across countries. This underscores the importance of tailored investment policies to optimize economic growth and stability.

4 Conclusion

This study undertook an empirical examination of the macroeconomic rates of return on public and private investments across 18 advanced economies from 1965 to 2019, employing the Vector Autoregressive (VAR) methodology. Our goal was to assess how public and private investments drive economic growth and to evaluate the crowding-in and crowding-out effects these investments exert on each other. Our findings reveal that public investment has contributed to economic growth in more than half of the countries studied, although its impact varies significantly across different national contexts. In countries where public investment did not spur growth, it tended to crowd out private investment, particularly in Belgium, Finland, Italy, Luxembourg, Norway, Sweden, the United Kingdom, and the United States. On the other hand, private investment

consistently demonstrated positive effects on economic growth across all countries, underscoring its vital role in national economic development. The sensitivity analysis, which reversed the order of private and public investments in the VAR model, offered additional insights into the interdependencies between these types of investment. Changes in marginal productivity and crowding effects under different model specifications underscore the complex relationship between public and private sectors. For example, while Germany and the Netherlands experienced substantial declines in public investment productivity, Sweden and Norway saw improvements, highlighting the significant influence of private sector dynamics on the effectiveness of public investment. Furthermore, the analysis revealed that while some countries exhibited stronger synergies between public and private investments, others experienced a reduction in negative interactions, indicating a shift toward more cooperative economic dynamics when the sequencing of investments changed. Overall, our research underscores the heterogeneous impacts of public and private investments on economic growth, emphasizing the need for nuanced economic policies that take into account both the specific economic contexts of individual countries and the interplay between different forms of investment. These findings suggest that policymakers should adopt flexible, informed approaches to fiscal planning and investment strategies, ensuring that both public and private sectors can effectively contribute to sustainable economic development.

5 Appendix 1

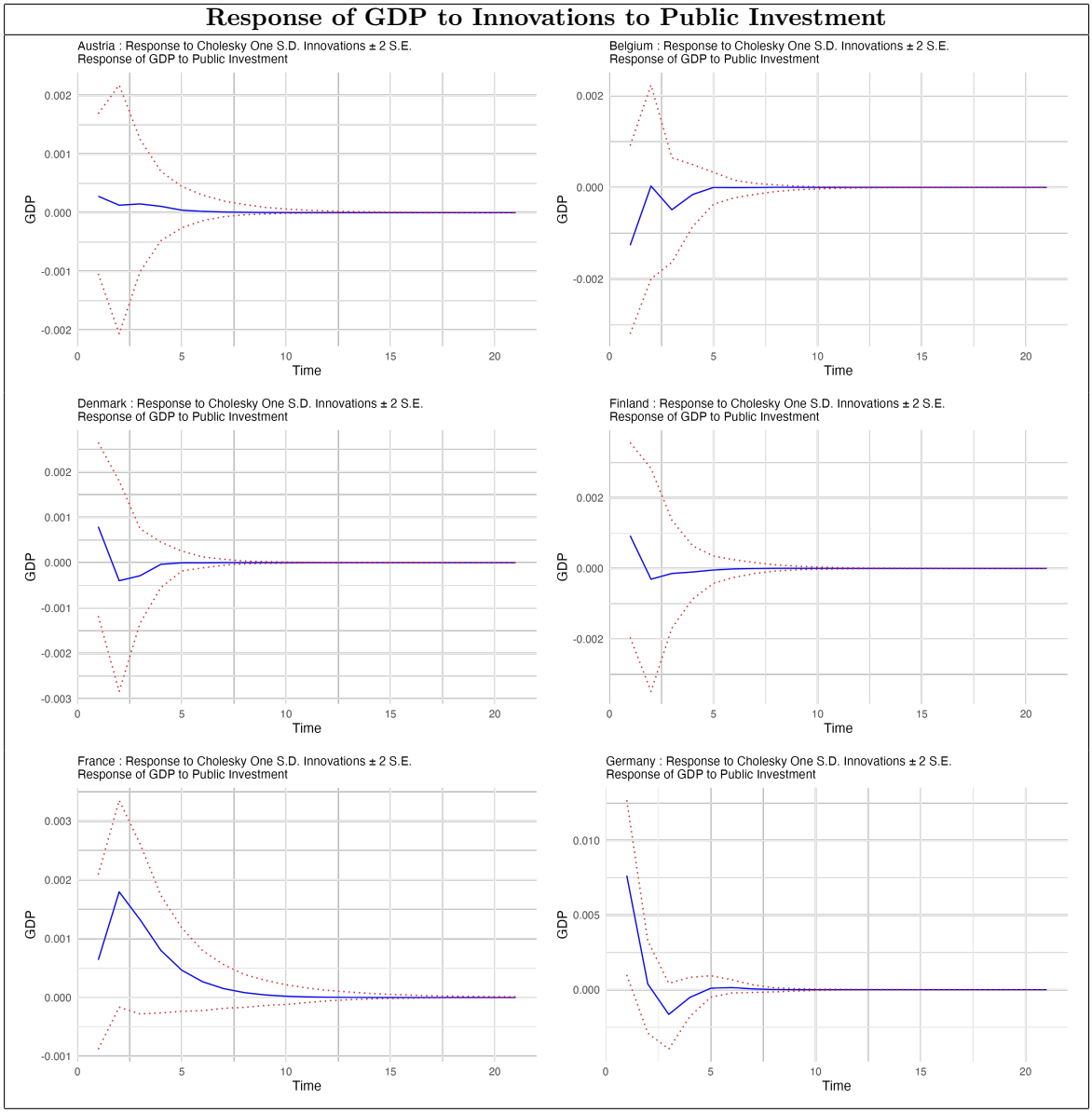


Figure 7: Response of GDP to Innovations to Public Investment

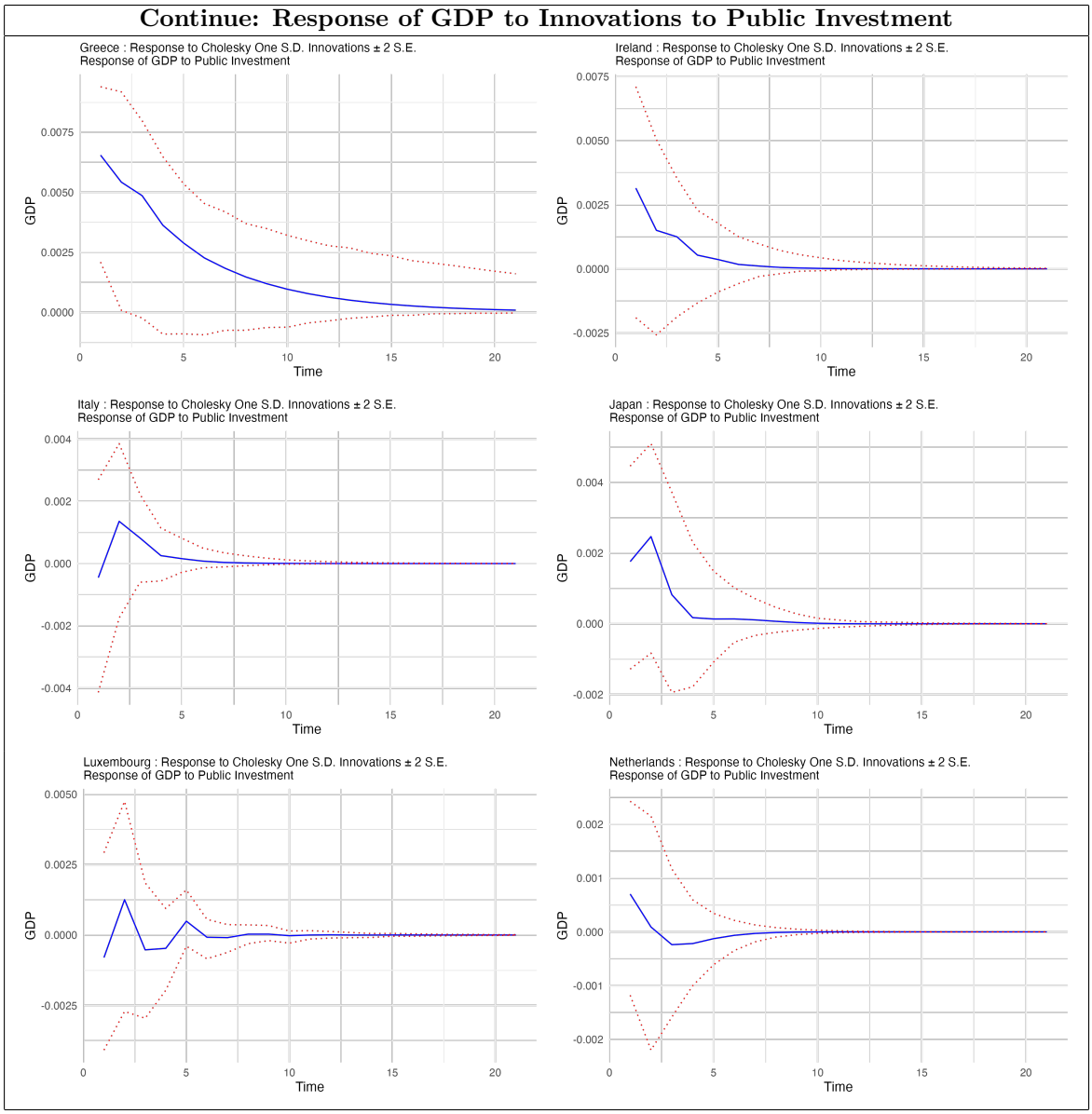


Figure 8: Response of GDP to Innovations to Public Investment

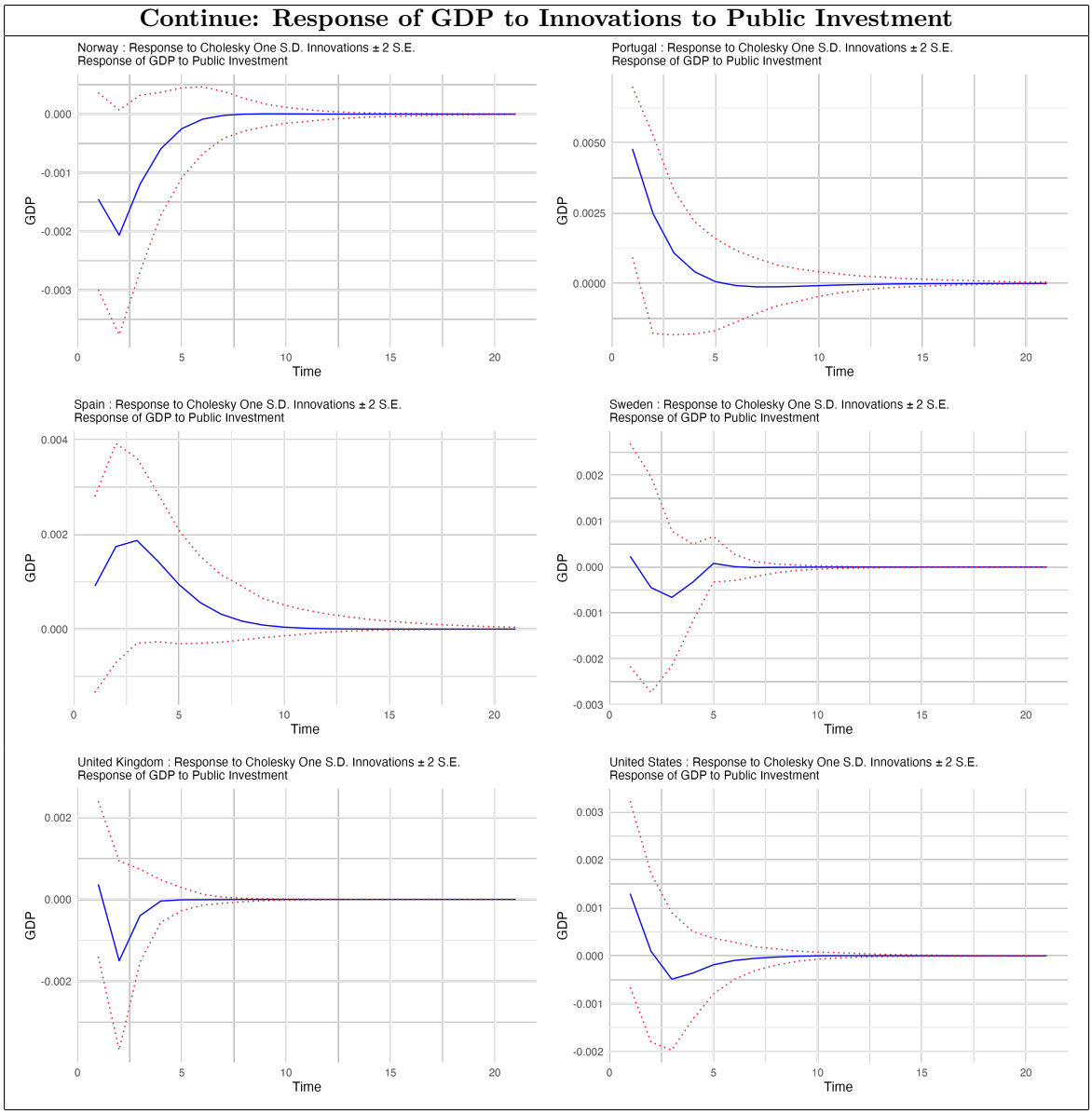


Figure 9: Response of GDP to Innovations to Public Investment

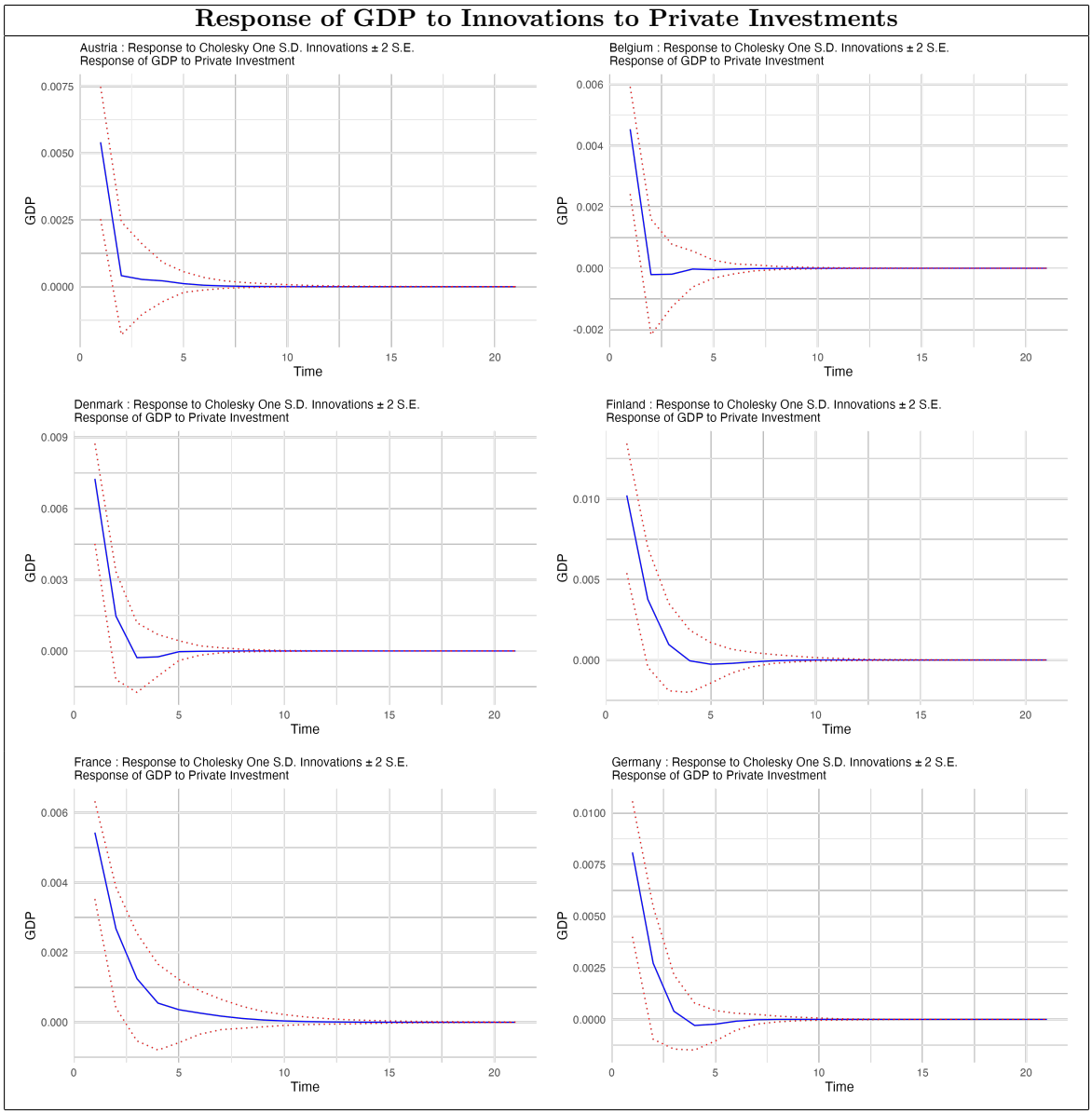


Figure 10: Response of GDP to Innovations to Private Investment

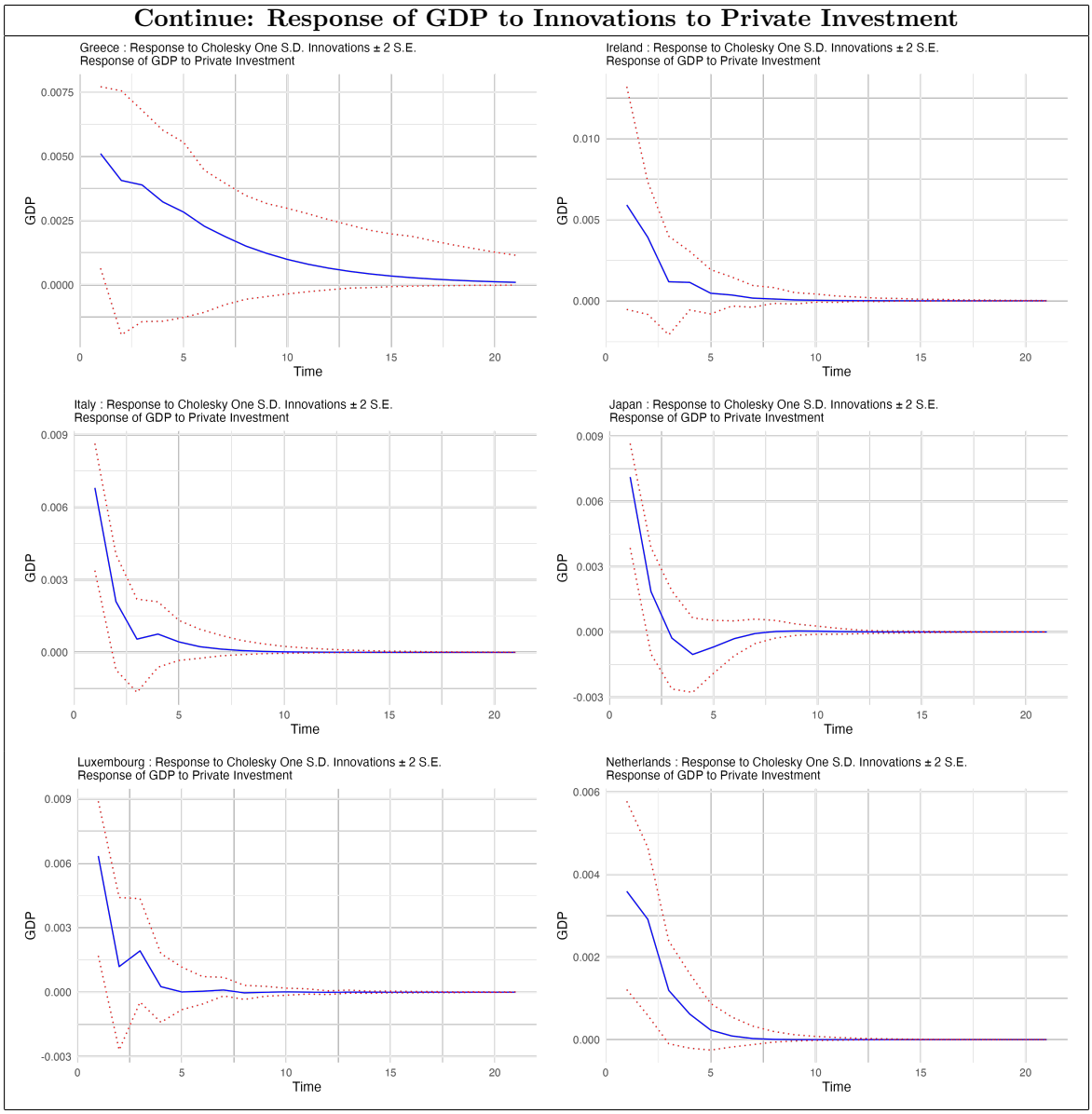


Figure 11: Response of GDP to Innovations to Private Investment

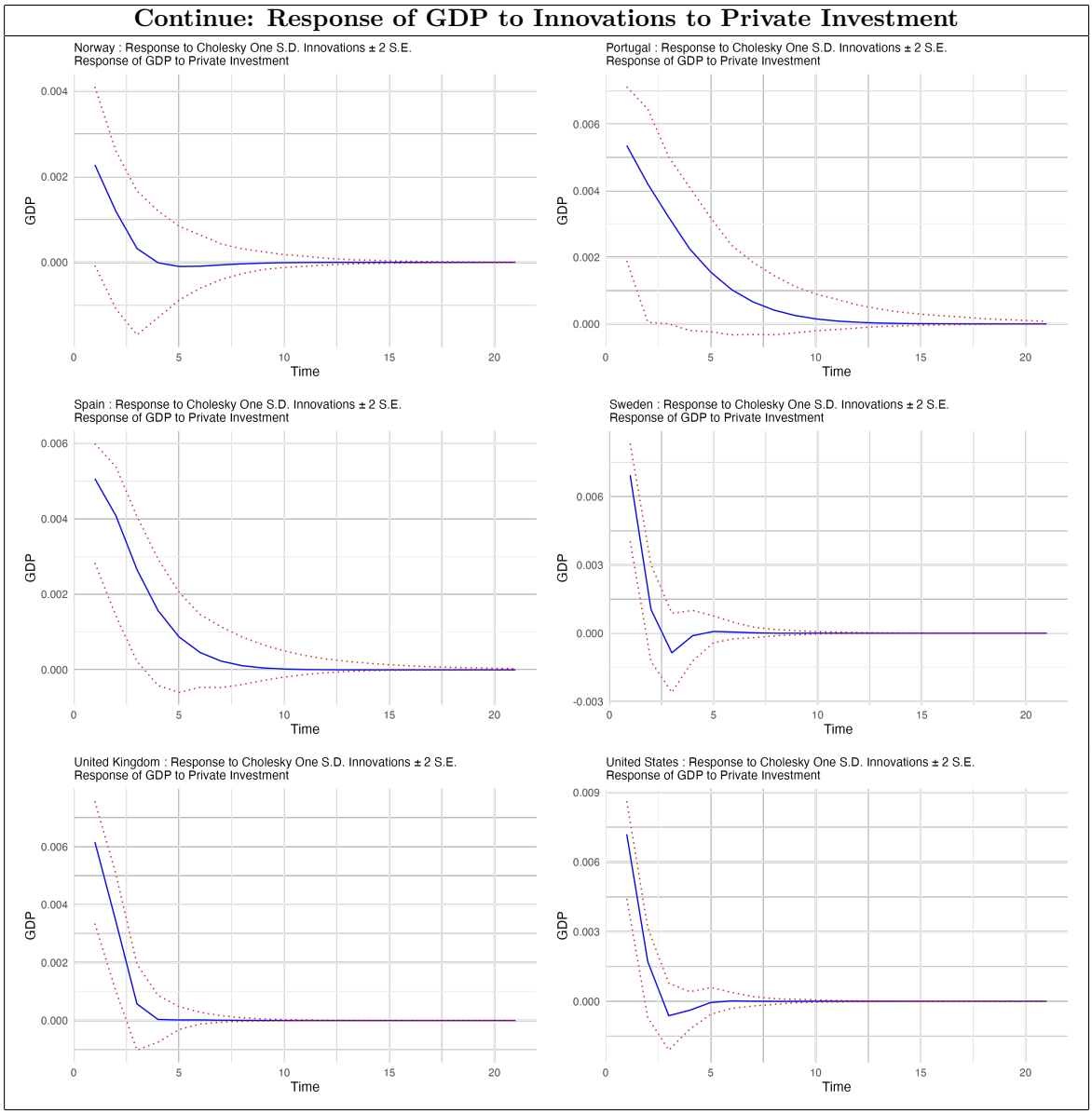


Figure 12: Response of GDP to Innovations to Private Investment

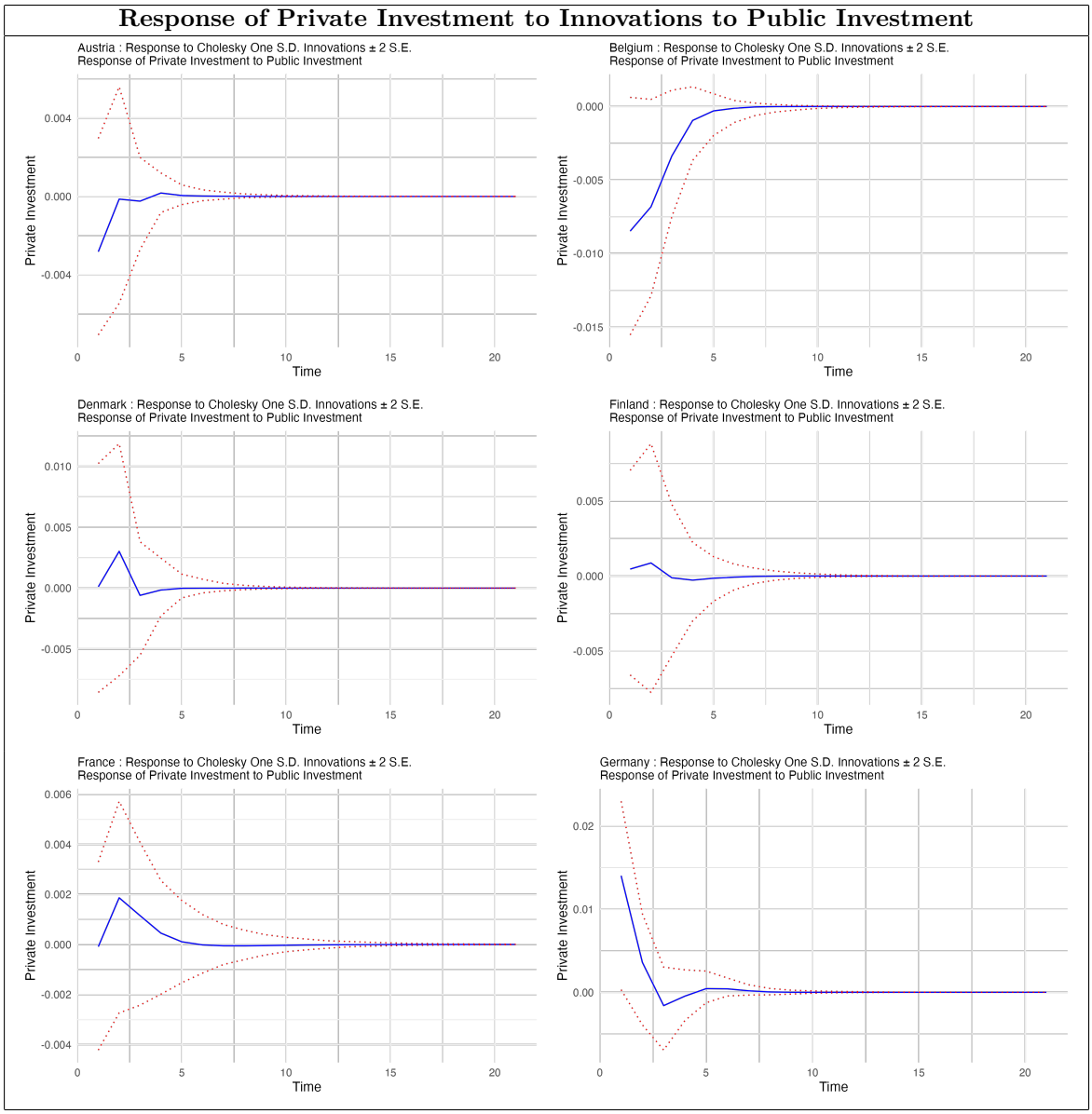


Figure 13: Response of Private Investment to Innovations to Public Investment

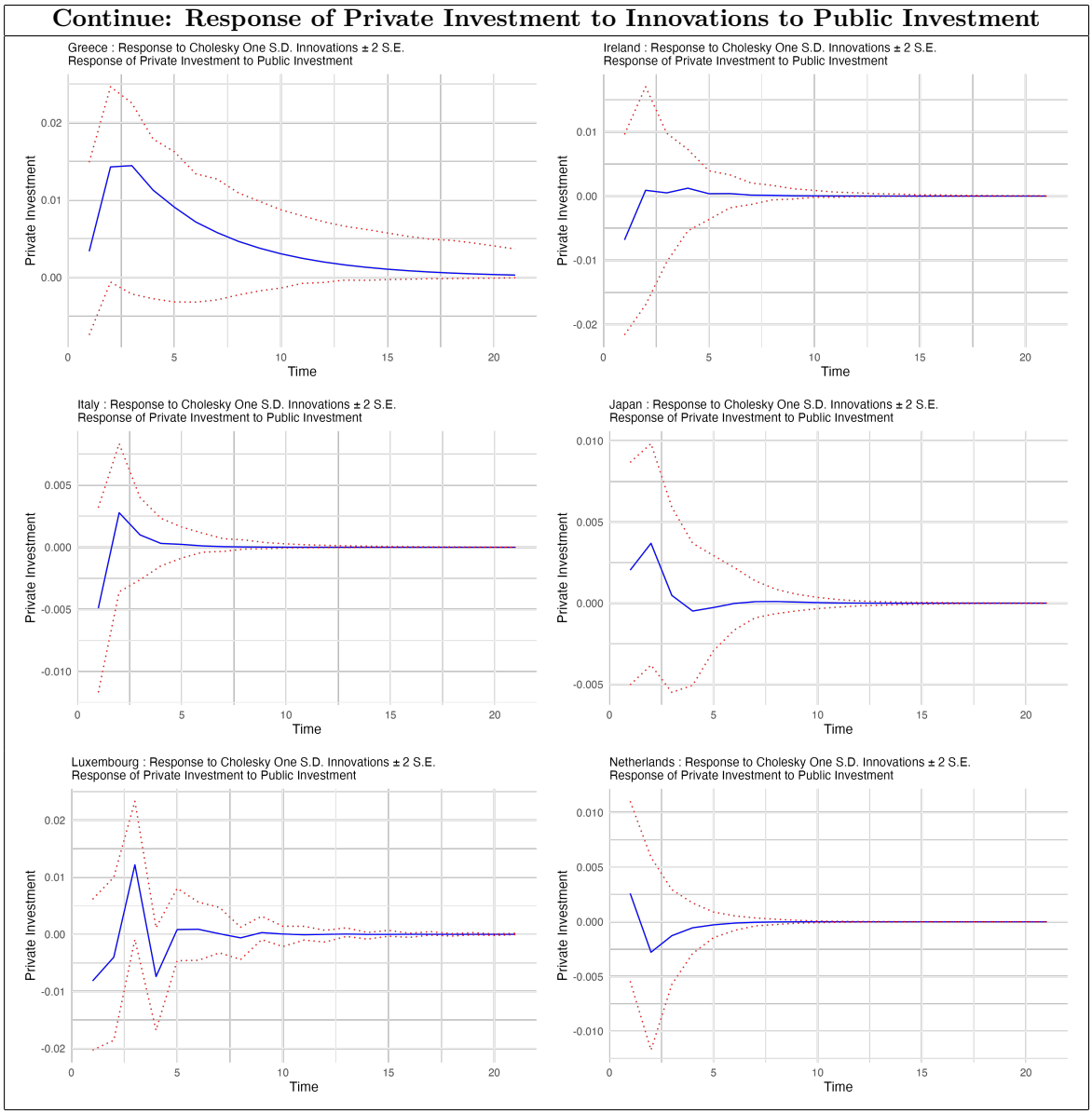


Figure 14: Response of Private Investment to Innovations to Public Investment

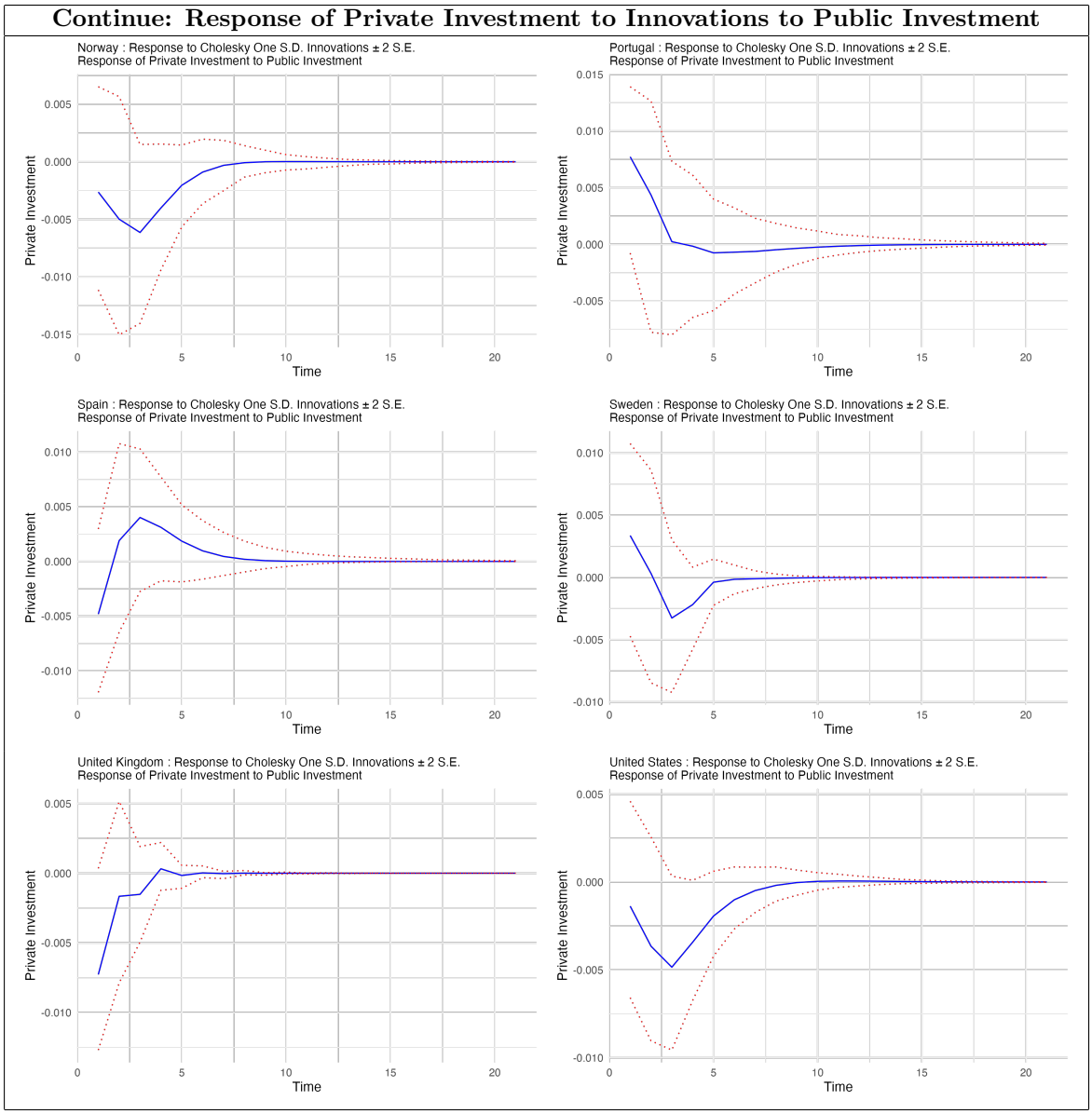


Figure 15: Response of Private Investment to Innovations to Public Investment

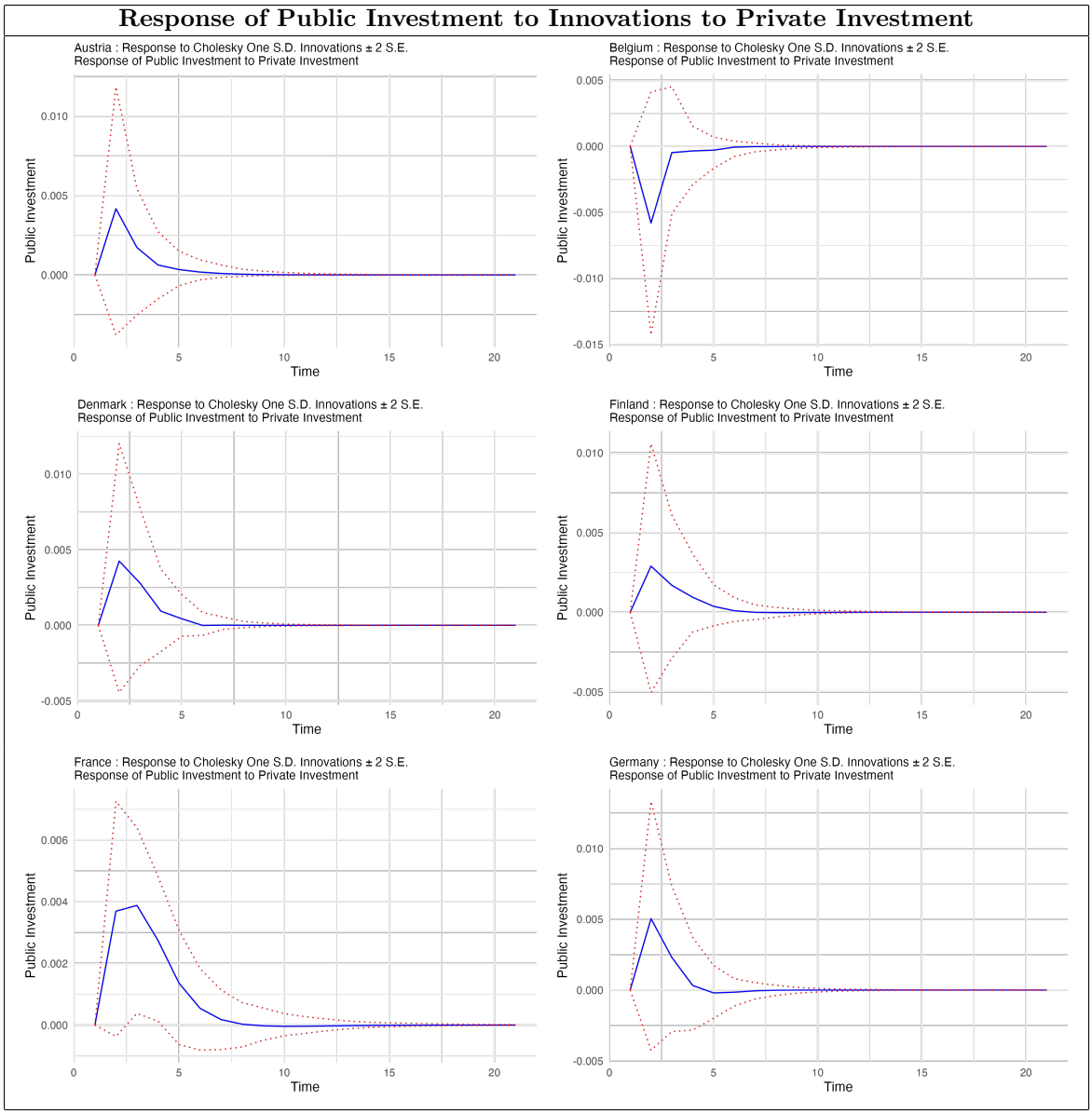


Figure 16: Response of Public Investment to Innovations to Private Investment

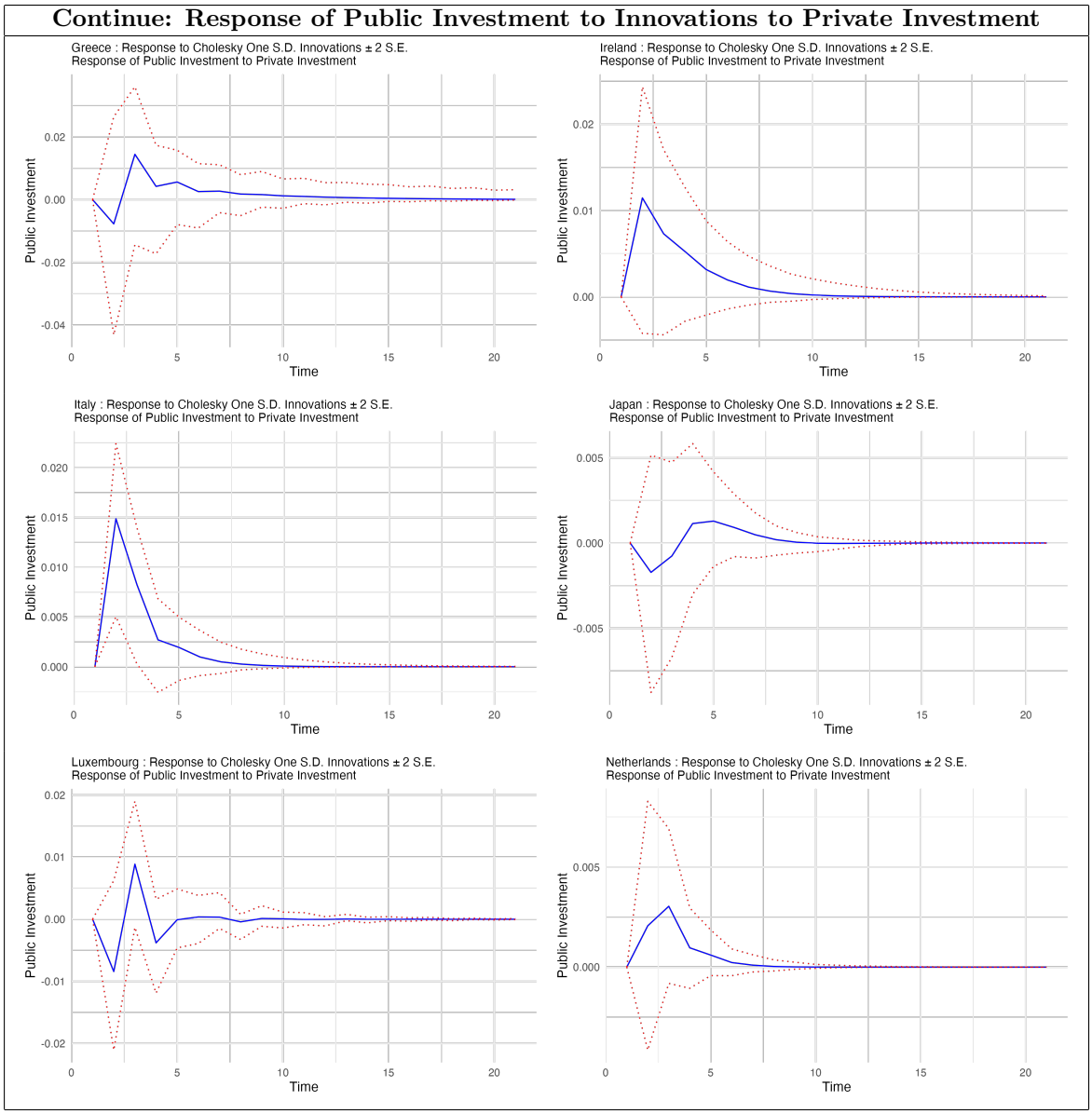


Figure 17: Response of Public Investment to Innovations to Private Investment

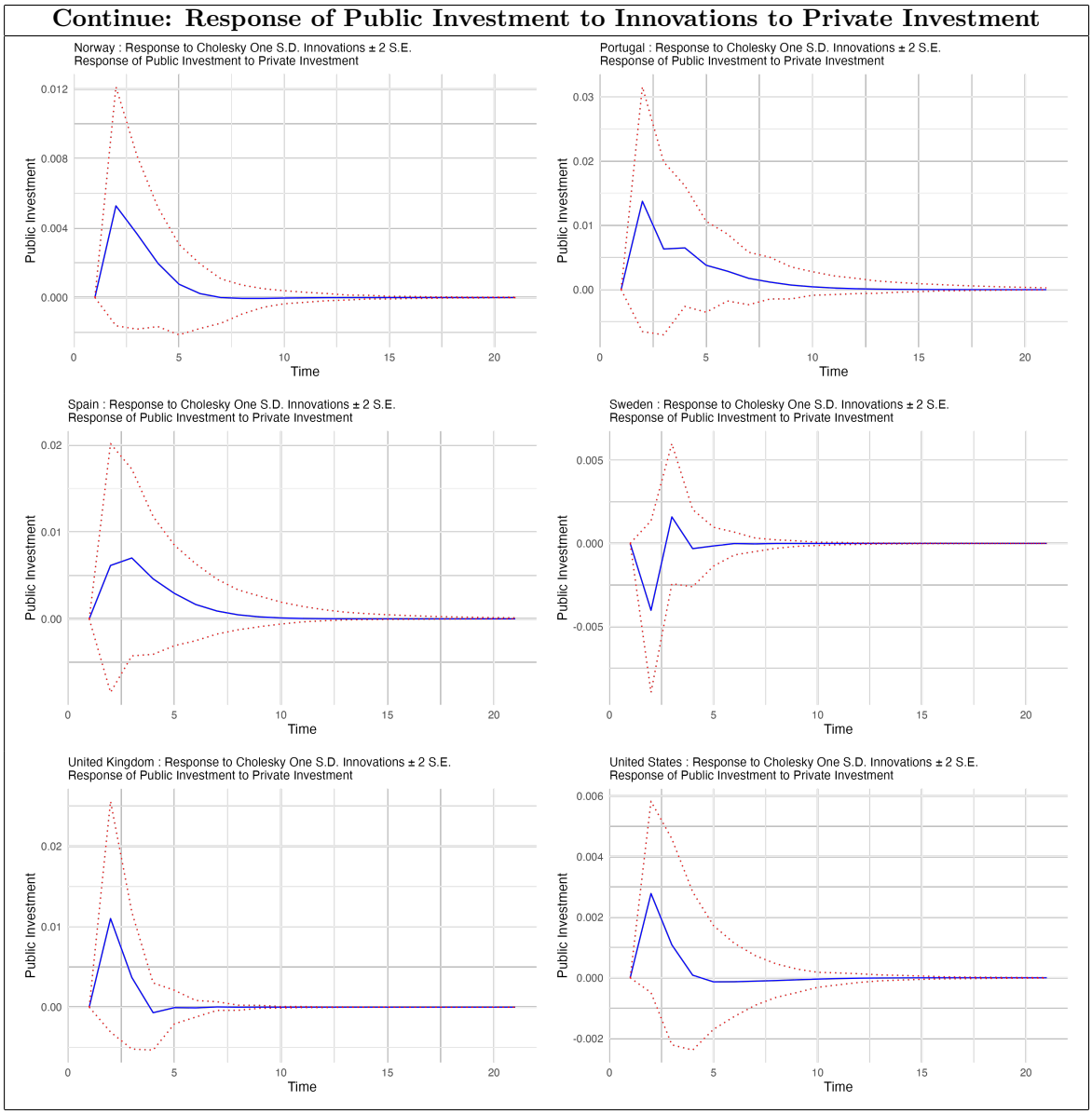


Figure 18: Response of Public Investment to Innovations to Private Investment

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