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Japan's Productivity and GDP growth: The Role of GBAORD, Public and foreign R&D

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Abstract We analyse the dynamic interaction of Japan's total factor productivity (TFP), GDP, domestic and foreign private and public R&D as well as mission-oriented R&D, GBAORD, in a cointegrated VAR for Japan with data from 1988-2014. Analysis of effects of permanent shocks shows that (i) public R&D, unlike GBAORD, encourages private R&D and TFP, and has high internal rates of return. (ii) Japan's public and private R&D have a statistically significant positive effect on foreign private and public R&D stocks and vice versa. (iii) After transitory GDP shocks, public and private R&D are counter-cyclical and GBAORD is pro-cyclical in Japan.

Keywords: R&D, productivity, growth, spillovers, vector-auto-regression (VAR).
JEL codes: F43, O19, O47, O53.

1. Introduction

Dynamic analyses of the effect of R&D on TFP have considered domestic private and public (non-business) and foreign total R&D stocks (Luintel and Khan 2004). Most recently, Soete et al. (2017) have distinguished between public and private foreign R&D stocks in a policy analysis for the Netherlands. In this paper, we also use all these four R&D variables and add mission-oriented R&D (GBAORD)[1]. GBAORD and public R&D stocks[2] are two important policy variables. The research questions are the following. Does public/non-business R&D affect business R&D? Does the mission-oriented type of R&D funding (GBAORD) affect business and non-business R&D? Do the three aforementioned variables together affect total factor productivity (TFP) and GDP? Do the returns, which are positive if the above effects are positive, outweigh the costs? Does Japanese R&D affect foreign R&D? Does foreign R&D affect Japanese R&D? As these are empirical questions, we use a method that lets the data speak, the vector autoregressive or cointegrated VAR approach. We consider these issues for Japan and explain the country specific aspects in due course below.

[1] The official expression is *Government budget appropriations or outlays for RD.* For a broad introduction, see Foray et al. (2012) and Mazzucato (2018).
[2] Public R&D stocks are obtained from accumulation of GERD-BERD (gross expenditure on R&D minus business expenditure on R&D) as explained below.

2. Data

The data for mission-oriented type of public R&D funding are *Government budget appropriations or outlays for RD (GBAORD)* as available from OECD-MSTI. GBAORD is the total sum of expenditure flows of these items from Government budget appropriations or outlays for R&D in several areas. The areas are Exploration and exploitation of the Earth; Environment; Exploration and exploitation of space; Transport, telecommunication and other infrastructures; Energy; Industrial Production and technology; Health; Agriculture; Education; Culture, recreation, religion and mass media; Political and social systems, structures and processes; General advancement of knowledge: R&D financed from General University Funds (GUF); General advancement of knowledge: R&D financed from other sources than GUF; Defence.

We take the total flows of GBAORD over all sub-items in $2005, PPP. From these we construct stock values using the perpetual inventory method with a standard rate of depreciation of 15% (Hall et al 2010; Luintel et al. 2014). Data are available for Japan 1988-2015, the period after a substantial reform of the patent system (Branstetter and Nakamura 2003) and after the study of Mansfield (1988) showing high R&D productivity, and starting just before the collapse of bank credit. This results in 28 data points for GBAORD. The GBAORD data overlap with business and non-business R&D (henceforth called 'public', abbreviated as PUBST), calculated as total R&D (GERD) minus business R&D (BERD, henceforth called 'private'). GBAORD expenditure flows are for many countries and years larger than GERD-BERD called 'public' (see Table 1 with value in 2010 PPP US dollars). For many countries, the ratio GBAORD/public in Table 1 falls over time, especially since about 1990. For Japan and Portugal, it is increasing.

Table 1	**GBAORD/(GERD-BERD)**																	
Year	AUT	BEL	CAN	DNK	FIN	FRA	DEU	GRC	IRL	ITA	JPN	NLD	NOR	PRT	ESP	SWE	GBR	USA
1981	1.0		0.9	0.9	1.1	1.6	1.5	1.0	0.9	1.5		1.1	1.2		1.2	1.4	1.5	1.5
1982			0.9	0.9		1.5	1.6		0.9	1.4		1.1	1.2		1.1			1.5
1983		1.3	0.9	0.9	1.0	1.5	1.5		0.9	1.5		1.1	1.1		1.1	1.5	1.5	1.5
1984	0.9	1.3	0.9	1.0	1.0	1.5	1.5		0.9	1.5		1.1	1.1		1.2			1.5
1985	1.0	1.3	0.9	1.0	1.0	1.6	1.5		1.0	1.4		1.0	1.1	0.9	1.3	1.4	1.5	1.5
1986		1.2	0.9	1.0	1.0	1.5	1.4	1.0	1.0	1.5		1.1		0.8	1.1		1.6	1.5
1987		1.2	0.9	1.0	1.0	1.5	1.4		1.0	1.5		1.2	1.2	0.9	1.3	1.3	1.5	1.6
1988		1.2	0.9	1.2	1.0	1.5	1.3	1.0	1.0	1.6	0.5	1.2		0.9	1.3		1.4	1.5
1989	1.0	1.0	0.9	1.1	1.1	1.5	1.3	0.9	0.9	1.4	0.5	1.2	1.1	0.8	1.5	1.2	1.4	1.5
1990			0.8	1.1	1.2	1.5	1.4		0.8	1.4	0.5	1.1		0.9	1.5		1.3	1.4
1991		1.0	0.9	1.0	1.1	1.5	1.3	0.8	0.9	1.4	0.5	1.0	1.2	0.9	1.4	1.4	1.3	1.4
1992			0.9	0.9	1.1	1.4	1.3		0.9	1.5	0.5	1.0		1.0	1.2		1.2	1.4
1993	1.0	1.1	0.8	0.9	1.2	1.3	1.3	0.6	0.9	1.3	0.5	0.9	1.1	1.0	1.1	1.3	1.2	1.4
1994		1.1	0.8		1.2	1.3	1.2		0.7	1.3	0.5	0.9		1.0	1.1		1.1	1.3
1995		1.1	0.8	0.9	1.2	1.2	1.2	0.8	0.9	1.2	0.5	0.9	1.1	1.0	1.2	1.3	1.1	1.3
1996		1.1	0.8	1.0	1.1	1.2	1.2		0.9	1.2	0.7	0.9		1.1	1.1		1.2	1.2
1997		1.1	0.7	1.0	1.2	1.2	1.1	0.8	0.8	1.1	0.7	0.9	1.0	1.1	1.2		1.2	1.3
1998	1.0	1.0	0.8	1.0	1.1	1.2	1.1		0.8	1.0	0.7	0.9		1.0	1.3		1.1	1.2
1999		1.1	0.7	1.0	1.0	1.2	1.1	0.6	0.9	1.0	0.7	0.9	1.0	1.0	1.3	0.8	1.1	1.2
2000		1.0	0.7		1.0	1.2	1.1		0.9	1.2	0.7	0.9		1.1	1.4		1.1	1.2
2001		1.0	0.7	1.0	1.0	1.2	1.1	0.7	1.0	1.2	0.8	0.9	1.1	1.1	1.5	0.9	1.1	1.2
2002	0.9	1.0	0.7	1.0	1.0	1.2	1.0		1.0		0.9	0.9	1.1	1.3	1.6		1.2	1.2
2003		1.1	0.7	0.9	1.0	1.2	1.0	0.7	1.0		0.9	0.9	1.1	1.2	1.5	0.9	1.1	1.2
2004	0.9	1.0	0.7	0.9	1.0	1.2	1.0	0.8	1.0		0.9	0.9	1.0	1.3	1.1	0.9	1.1	1.3
2005		1.0	0.7	0.9	1.0	1.2	1.0	0.8	1.0	1.2	0.9	0.9	1.0	1.5	1.1	0.9	1.0	1.3
2006	0.9	1.1	0.7	0.9	1.0	1.0	1.0	0.8	1.0	1.1	0.9	0.9	1.0	1.3	1.3	0.9	1.0	1.3
2007	0.9	1.0	0.7	1.0	1.0	1.0	1.0	0.7	1.1	1.1	0.9	0.9	1.0	1.3	1.4	0.9	1.0	1.3
2008		1.1	0.7	1.0	1.0	1.1	1.0		1.0	1.1	1.0	0.9	1.0	1.2	1.3		0.9	1.2
2009	0.9	1.0	0.7	1.1	1.0	1.1	1.0		1.0	1.1	0.9	0.9	1.0	1.2	1.2	0.9	0.9	1.3
2010		1.0	0.7	1.0	1.0	1.0	1.0		1.0	1.1	1.0		1.0	1.2	1.2		0.9	1.1
2011	0.9	0.9	0.6	1.0	1.0	1.0	1.0	0.7	1.0	1.0	1.0	0.9	1.0	1.3	1.1	0.8	0.9	1.1
2012		0.9	0.6	1.0	1.0	0.9	1.0		1.0	0.9	1.0	0.9	1.0	1.3	1.0		0.9	1.1
2013	0.9	0.9	0.6	0.9	1.0	0.9	1.0	0.9	0.9	0.9	0.9	0.8	1.0	1.3	0.9	0.8	1.0	1.0
2014				0.9	1.0	0.9	0.9		0.9	0.8	0.9	0.8	1.1	1.4	1.0		1.0	1.0
2015											0.9							1.0

For each country, there is a distance-weighted average of public and private foreign R&D stocks. Domestic and foreign private and public R&D stocks (abbreviated as BERDST, FBERDST, PUBST, FPUBST), calculated in the same way as indicated above for GBAORD, are taken from UNU-MERIT data base as in Soete et al (2017).[3] These data are available for the period 1963-2014, reducing our data points to 1988-2014. The implied number of 27 data points makes a VECM analysis just possible. GDP data are taken from World Development Indicators and are transformed into 2005 PPP dollars. TFP data are from PWT9; they also go until 2014. They do not include human capital (Feenstra et al

[3] Special thanks go to Bart Verspagen for providing these data.

2015). We do not use human capital as a separate variable because it is included in R&D expenditures.[4] There have been revisions in Japan's R&D data in 1996, 2008, 2013.

3. Methodology

3.1 The cointegrated VAR or VECM approach

We use the regression approach for dynamic simultaneous equation estimation, in particular the cointegrated VAR or vector-error-correction (VEC) approach. This approach generates a difference equation system in the seven variables mentioned above; assuming from the beginning that they are all endogenous unless testing shows the opposite. It goes beyond single equation estimation because we take the mutual interaction between all the variables mentioned above into account in estimation, and in simulation and shock analysis. We write a VAR in levels as follows:

$$y = A_1 y(-1) + A_2 y(-2) + Cx + u \tag{1}$$

All variables are dependent on the lags of all others.[5] In the presence of unit roots and cointegration, a VECM approach is more appropriate. In particular, r cointegrating equations, CE, provide information on long-term relations in addition to a VAR model in differences.

$$dy = \alpha\beta' y(-1) + B\, dy(-1) + Fx + u \tag{2}$$

Here dy is the (7, 1)-vector (7 rows, 1 column) of first differences of the $K=7$ variables introduced above. If the term $\alpha\beta' y(-1)$ were absent, we would basically have a system for the seven variables in differences regressed on the lags of all seven differenced variables. Estimation in differences avoids problems from variables with unit roots, which means that they are dependent on their own lag with coefficient unity. A_p or B is the (7, 7) matrix of coefficients of the (7, 1)-vector of lagged terms with lag $p = 1,2$ (and perhaps more or less). C and F are a (7, 2)-matrices of the coefficients of the vector of exogenous variables $x' = (c, t)$, in the first instance only constant and time trend; here we also add unit

[4] In contrast, OECD measures of TFP do include human capital as only labour and capital are subtracted from GDP. As R&D also includes human capital a regression of both including a third human capital variable as found in some articles is likely to be strong because of the common human capital data included and may lead to multi-collinearity.
[5] Unlike other areas, we do not assume that there is another model with contemporaneous regressors behind it.

dummies for the periods before the data revisions. β is a *(7,r)*-matrix of coefficients of the log-term relations, where cointegration tests provide the number *r;* it may include a constant and a coefficient for a time trend. $\beta'y(-1) = E(u(-1)) = 0$ represents the long-term relations, which in addition may also include a time trend and a constant, and α is the *(7, r)*-matrix of adjustment coefficients indicating how strongly the model react to dis-equilibrium, $u(-1) \neq 0$. The econometric analysis of cointegrated variables leads to several possible outcomes. If the result from cointegration tests is $r = 0$, no cointegration, equation (2) should be estimated without the term $\alpha\beta'y(-1)$; if $0 < r < K$, equation (2) is estimated as written; if $r=K$ there are no unit roots and the model can be estimated in levels as in equation (1) (see Davidson and Mackinnon 2004). If all adjustment coefficients α for one of the seven equations turn out to be insignificant, that variable is called weakly exogenous. If this variable is also statistically insignificant in all long-term relations $\beta'y(-1)$, we will have an additional exogenous variable x with coefficient matrix *F* extended and the number of endogenous variables is reduced by one. The practical difficulty here is to find the number *r* of long-term relations. We use the trace test and the maximum-eigenvalue test. Hjalmarsson and Österholm (2010) suggest rejecting a null hypothesis of having at most *r* cointegrating equations - and by implication at least *K-r* unit roots - in the presence of near unit roots only if both tests reject it. This leads to a conservatively low number of cointegrating relations. This is slightly different from the suggestion of Jusélius et al (2014) to be aware of the low power of unit root tests and be conservative against the hypothesis of having a unit root; one would choose a low number of unit roots *K-r* and therefore a high number of cointegrating equations, *r*. The estimation method is maximum likelihood.

In the second step, we will carry out model-shock analysis by way of increasing the intercept of the equation(s) for domestic public R&D, GBAORD, private R&D and foreign private and public R&D by 0.005, a half percentage point, and comparing the old and the new solution. This can show whether or not additional GBAORD or public R&D generates positive effects on business R&D, TFP and GDP and what the rates of return are. We analyse also shocks to private R&D in order to see how it affects the other variables, in particular foreign R&D variables, and shocks to foreign public and private R&D stocks in order to see whether Japan obtains positive knowledge spillovers or predominantly negative competition effects. Finally, shocks to GDP or TFP can tell which R&D variables are pro- or counter-cyclical.

3.2 Net gains and internal rates of return.

The benefit from shocks on R&D and GDP variables for each year is the achieved difference of the GDP from baseline. The additional costs are 0.005 of the R&D shock variable in the initial year, and later the yearly additional private and public investment. The method of using shocks in a dynamic model results in exact numbers of yearly changes in real time. Subtracting the yearly costs from the yearly benefits yields the yearly gains. Discounting them at a conventional rate of 4% allows adding them up and seeing whether they are positive. In addition, when the costs precede the benefits one can calculate the internal rate of return (*irr*), which is the discount rate that brings the sum of discounted present values to zero. This latter method may be problematic though for cases where gains go from negative to positive and then to negative and to positive again.[6]

4. Estimation results for the cointegrated VAR model

Uni-variate ADF unit root tests with break point test show a unit root in GBAORD, LGBST, and near unit roots for LGDP, LTFP and LPUBST, where the L indicates a natural logarithm. The p-values would not reject the unit root hypothesis but they are not very high and the lagged dependent variables are clearly below unity. Taking into account the low power of unit root tests with low numbers of observations the most plausible interpretation is having only near-unit roots except for GBAORD, LGBST.

For the VAR model, the optimal lag length is two. The model is stable. The Doornik-Hansen version of the Jarque-Bera test for the null hypothesis of multivariate normality has $p=0.31$. The LM test for the null of no serial correlation shows presence of serial correlation indicating that caution is important in interpreting the results. Heteroscedasticity tests generate a near singular matrix warning and

[6] This method using the exact time resolution from a VECM for the rate of return calculation, has first been developed and used in the related R&D literature by Soete et al. (2017).

therefore give no result. The VAR model without the dummies for the periods before data revisions would produce a negative effect of private R&D on TFP, which is implausible and therefore we should use these dummies. Without including the GBAORD variable, we would miss the information from Table 1 that the ratio of it with public R&D has gone from 0.5 to unity. This relative GBAORD variable is an important variable of policy induced structural change.

The trace test and the maximum eigenvalue test for the number of cointegrating equations both show rank $6 = r = K\text{-}1$, at the 5 or 10 percent level (both with p=0.114), implying that they can be estimated as vector-error-correction model. By implication, there is only one unit root and the others are only near unit roots. When estimating a vector-error correction model we set adjustment coefficients with t < 1 to zero unless this makes the models unstable. When going to stricter values the p-value for the chi-square test on all restrictions decreases strongly; this may be legitimate but the model then goes away from 'letting the data speak'. The t-values for adjustment coefficients shown in equation (9)-(15) below suggest that we are not very restrictive in setting coefficients to zero. The model is stable also after imposing the constraints. The long-term relations with t-values in brackets are as follows.

$$CE1= E(u_1(-1)) = 0 = LGDP(-1) - \underset{[-52.3]}{4.45}LTFP(-1) - \underset{[-3.53]}{0.0167}t - 14.4 \tag{3}$$

$$CE2= E(u_2(-1)) = 0 = LTFP(-1) - \underset{[-49.8]}{0.177}LBERDST(-1) + \underset{[7.6]}{0.00758}t + 1.99965 \tag{4}$$

$$CE3= E(u_3(-1)) = 0 = LBERDST(-1) - \underset{[-113.25]}{1.957}LPUBST(-1) - 0.013t + 11.2 \tag{5}$$

$$CE4= E(u_4(-1)) = 0 = LPUBST(-1) + \underset{[344.1]}{1.55}LGBST(-1) - \underset{[-3.32]}{0.0366}t - 28.9 \tag{6}$$

$$CE5= E(u_5(-1)) = 0 = LGBST(-1) + \underset{[121.6]}{1.53}LFBERDST(-1) - \underset{[-7.42]}{0.059}t - 28.15 \tag{7}$$

$$CE6= E(u_6(-1)) = 0 = LFBERDST(-1) - \underset{[-19.75]}{0.52}LFPUBST(-1) - \underset{[-11.4]}{0.0149}t - 5.63 \tag{8}$$

An alternative way of writing these equations would be to put all but the first term from the right-hand side to the left with the due change in sign. The cointegrating equations show important results. The basic mechanism of thinking about R&D works well in Japan: Domestic public R&D has a positive impact on private R&D, LBERDST, in equation (5), which in turn has a positive partial long-term impact on LTFP in equation (4); LTFP has a positive partial long-term effect on LGDP in equation (3).[7] GBAORD, LGBST, seemingly not analysed before in the modelling literature, has a negative effect on public R&D in equation (6); this relation is the counterpart, in terms of stocks, to the shift in the flow ratio in Table 1. Foreign private R&D has a negative effect on GBAORD in equation (7). Foreign public R&D has a positive long-term impact on foreign private R&D in equation (8), analogous to the effect in Japan equation (5), where the effect is larger. All variables are de-trended by the time trend t (see Wooldridge 2013, chap 10.5). Exogenous time trends in the long-term relation and constants in the equations for the growth rates make sure that all variables grow in the stable steady state. However, six long-term relations can determine only six variables and therefore the whole system determines ultimately all the variables for each point in time. These long-term results are only partial effects. Moreover, the long-term relations in general are valid for two-way causality. Ultimately, all variables depend on the solution of the whole system.

The common belief that foreign R&D capital stocks have stimulated Japan's R&D (Luintel and Khan 2004) is supported here for the long-term effect of foreign public R&D stocks with a positive effect on foreign private R&D, which in turn has an impact via (7) on (5) and (6). For the reverse impact of Japan, we look at shock effects below in section 6.

The complete model for the estimation period 1989-2014, abbreviating the long-term relations as CE1, …, 6 as in equations (3) to (8), is as follows. We use as abbreviation *Y* for *LGDP*, *A* for *LTFP*, *B* for *LBERDST*, *P* for *LPUBST*, a '*' for the corresponding foreign variables and *D* for the first difference with respect to time (t-values in parentheses presented only for adjustment coefficients).

[7] The coefficient is large here because TFP is falling for long sub-periods whereas GDP is growing. Even at stagnant TFP the economy could grow at a rate of 1.6%. Strongly demanded exports allow buying investment goods beyond the own production (diminished export) of capital goods. However, this line of thought goes beyond the scope of this paper.

$$D(Y) = -3.27CE1 - 14.16CE2 - 1.2CE3 - 1.02CE4 + 1.745CE5 - 3.375CE6 \quad (9)$$

[-2.15] [-2.24] [-3.3] [-1.82] [2.2] [-2.24]

$$+ 1.355D(Y(-1)) - 0.75D(A(-1)) + 2.5D(B(-1)) + 1.4D(P(-1)) + 1.75D(G(-1)) - 0.054D(B^*(-1)) - 0.17D(P^*(-1)) - 0.176 - 0.025DUM96 + 0.028DUM08 - 0.03DUM13$$

$$D(A) = -1.88CE1 - 9.459CE2 - 1.27CE3 - 1.8CE4 + 2.795CE5 - 4.36CE6 \quad (10)$$

[-1.50] [-1.81] [-4.56] [-6.28] [6.51] [-3.77281]

$$+ 0.5D(Y(-1)) + 0.066D(A(-1)) + 3.03D(B(-1)) + 1.567D(P(-1)) + 1.459D(G(-1)) + 0.198D(B^*(-1)) - 0.63D(P^*(-1)) - 0.185 - 0.025DUM96 + 0.013DUM08 - 0.019DUM13$$

$$D(B) = -0.7CE1 - 2.5CE2 - 0.29CE3 + 0CE4 + 0.06CE5 - 0.38CE6 \quad (11)$$

[-1.17] [-0.985] [-2.23] [NA] [0.776] [-0.7]

$$- 0.045D(Y(-1)) + 0.059D(A(-1)) + 0.8D(B(-1)) + 0.176D(P(-1)) - 0.06D(G(-1)) + 0.017D(B^*(-1)) + 0.26D(P^*(-1)) - 0.017 - 0.01DUM96 + 0.02DUM08 + 0.003DUM13$$

$$D(P) = 0.3CE1 + 1.17CE2 + 0.36CE3 + 0.15CE4 - 0.2CE5 + 0CE6 \quad (12)$$

[1.03] [0.9] [4.48] [0.75] [-0.84] [NA]

$$- 0.235D(Y(-1)) + 0.18D(A(-1)) - 0.3D(B(-1)) + 0.5D(P(-1)) + 0.36D(G(-1)) + 0.32D(B^*(-1)) + 0.84D(P^*(-1)) - 0.0179 + 0.0095DUM96 + 0.0084DUM08 - 0.015DUM13$$

$$D(G) = 0.075CE1 + 0CE2 - 0.17CE3 - 0.24CE4 + 0.27CE5 - 0.268CE6 \quad (13)$$

[2.175] [NA] [-3.76] [-1.885] [1.54] [-1.52]

$$+ 0.1D(Y(-1)) + 0.0034D(A(-1)) + 0.17D(B(-1)) - 0.029D(P(-1)) + 0.18D(G(-1)) + 0.1D(B^*(-1)) + 0.43D(P^*(-1)) + 0.01 - 0.01DUM96 - 0.007DUM08 + 0.0035DUM13$$

$$D(B^*) = -0.33CE1 - 1.37CE2 + 0.074CE3 + 0.34CE4 - 0.43CE5 - 0.48CE6 \quad (14)$$

[-1.35] [-1.376] [1.05] [2.57] [-2.23] [-1.766]

$$- 0.07D(Y(-1)) + 0.16D(A(-1)) + 0.4D(B(-1)) + 0.478D(P(-1)) + 0.259D(G(-1)) + 1.18D(B^*(-1)) + 1.9D(P^*(-1)) - 0.09 + 0.0016DUM96 + 0.0019DUM08 - 0.004DUM13$$

$$D(P^*) = -0.2CE1 - 0.86CE2 - 0.0244CE3 + 0CE4 + 0CE5) + 0.27CE6 \quad (15)$$

[-2.87] [-2.798] [-1.255] [NA] [NA] [3.12]

$$+ 0.033D(Y(-1)) + 0.00785D(A(-1)) + 0.0236D(B(-1)) - 0.167D(P(-1)) - 0.03D(G(-1)) + 0.07D(B^*(-1)) - 0.13D(P^*(-1)) + 0.027 + 0.00074DUM96 + 0.0012DUM08 + 0.00456DUM13$$

Adj. R-squared for equations (9)-(15) are 0.488, 0.566, 0.9, 0.956, 0.986, 0.89, 0.97. The lowest t-value is the last term in equation (11). The coefficient is not small though and putting the adjustment coefficient to zero causes a large drop in the p =0.90 of the chi-square statistic testing the constraints.

Figures 1 and 2 below include the baseline scenario and the data, showing that TFP falls from 1974 to 1999 (with an exception of the period 1984-88) and then remains roughly constant with ups and downs. In contrast to the PWT9 measure of TFP used here, the OECD TFP measure, including human capital, has a positive growth rate (see Luintel et al. 2014). Hayashi and Prescott (2002) and Kaihatsu and Kurozomi (2014) interpret the trend in TFP (not corrected for human capital) as exogenous. However, here TFP is endogenous as adjustment coefficients are statistically significant in equation (10). Other authors point to effects of financial problems affecting GDP. We will look at this argument in section 6 in the form of a transitory shock. For the period of stagnation, Bottazzi and Peri (2007) point out that R&D employment is stagnant in Japan. This goes together in our data with decreasing growth rates of domestic private and public R&D. Branstetter and Nakamura (2003) point out that private R&D expenditure flows have stagnated or grown slowly during the 1990s leading to mostly decreasing growth rates of private (and public) R&D stocks in our data and simulations below. Branstetter and Nakamura (2003) defend stagnant human capital supply as a cause of stagnant R&D employment for PhD-level engineers, and Arora et al (2013) for IT software and Kim (2016) for durable manufactured goods. Arora et al (2013) argue that Japanese immigration practices are restrictive, offshoring is not used much, and domestic graduates are scarce. Goto (2000) mentions the low number of PhD grants in Japan. Consequently, Japanese firms do software-skill intensive research in the USA and patent there. All explanations seem to be complementary and in line with our R&D stock data and our model.

The critical question then is what is behind the slow growth that tears R&D growth and TFP levels down. It is beyond the scope of this paper to give a full explanation but some of the relevant reasons may be the following:

(i) Stagnant R&D employment discussed above and caused by a limit in human capital supply; R&D expenditure then drives up only human capital prices. This also may help explaining the large coefficient of LTFP in equation (3).

(ii) Kim (2016), finding a negative though insignificant sign of private R&D on TFP on the firm level in Japanese manufacturing, argues that R&D expenditure may go to foreign subsidiaries and thereby reducing the productivity of headquarters.

(iii) The number of researchers as a share of the population may be too high in Japan (see Goto 2000, Table 1) leaving too little high skilled workers for production. If many are doing research there may be insufficiently many scientists and engineers to cooperate in development and production; a given accounting number at the macro-level may go together with an imbalance between the number of researchers and applying engineers (see Grossman 1989 for the theoretical underpinning). The Japanese tax system may support such an imbalance because it allows deducting changes rather than levels in R&D expenditure from the sum of taxes paid (Goto 2000). The incentive then is to go beyond optimum R&D expenditures. This may be a reason why Japanese firms have strengthened research at the cost of productivity in production. The literature, studied so far for this paper, shows that R&D in Japan is strong in every type of input, but it does not look at engineers in production. Moreover, if all researchers are fully employed additional R&D expenditure may increase wages more than hiring, which increases GDP but makes TFP enhancing projects less profitable.

(iv) Shifts of sector shares to low productivity sectors may be an important element. Interpreting macro TFP as a weighted sum of sectoral TFPs, sectors with below average productivity possibly gain as shares of GDP in the period with negative growth rates when old industries are defended against the market trends and exiting firms are more productive than staying firms (Fukao and Kwon 2004). An example is government subsidies for specific technologies like a smelting process (see Peck et al. 1987), which goes beyond technological neutrality. The negative national spillovers found by Bernstein and Yan (1996) and the decreasing spillovers from large to smaller found by Fukao (2013) firms may be part of this. In recent years, the fall of Japanese sectors behind their US competitors (Branstetter and Nakamura 2003) may have continued this effect. Fukao and Kwon (2004) state that ‘while TFP growth decelerated in many manufacturing industries, it picked up in non-manufacturing industries’;[8] the strongest counterpart in the rise of services as a share of GDP is the fall of non-manufacturing industries, implying that sectors with stronger TFP growth are shrinking relatively more.

(v) Falling capacity utilisation and exit of efficient firms may have contributed to this (Jones and Yokoyama 2003).

Finding the exact contribution of the most important causes for the decline of TFP is a topic going beyond the scope of this paper.

The small literature on cyclicality of R&D suggests that it most happens to be pro-cyclical with exceptions though.[9] The negative effect found in Pellen et al. (2017) is therefore in line with our short-term estimation result for public R&D. Again, it needs to be seen whether the partial effects are confirmed by a more comprehensive analysis applying transitory shocks to the GDP variable in section 6.

5. Results for GBAORD, public and private R&D shocks

The results described so far only indicate regression coefficients but do not include indirect effects of all variables influencing each other mutually. In particular, variables that have no direct impact can have indirect impacts via other variables. To see this explicitly we impose a shock of 0.005 on the constant of the public investment equation (DLPUBST) in scenario 1 and on the constant of GBAORD stock (LGBST) in scenario 2. The Figures show the results for these shocks.

[8] Most studies discussed in Fukao and Kwon (2006) seem to show the opposite result though.
[9] See Pellen et al. (2017) and Cruz-Castro and Luis Sanz-Menéndez (2016).

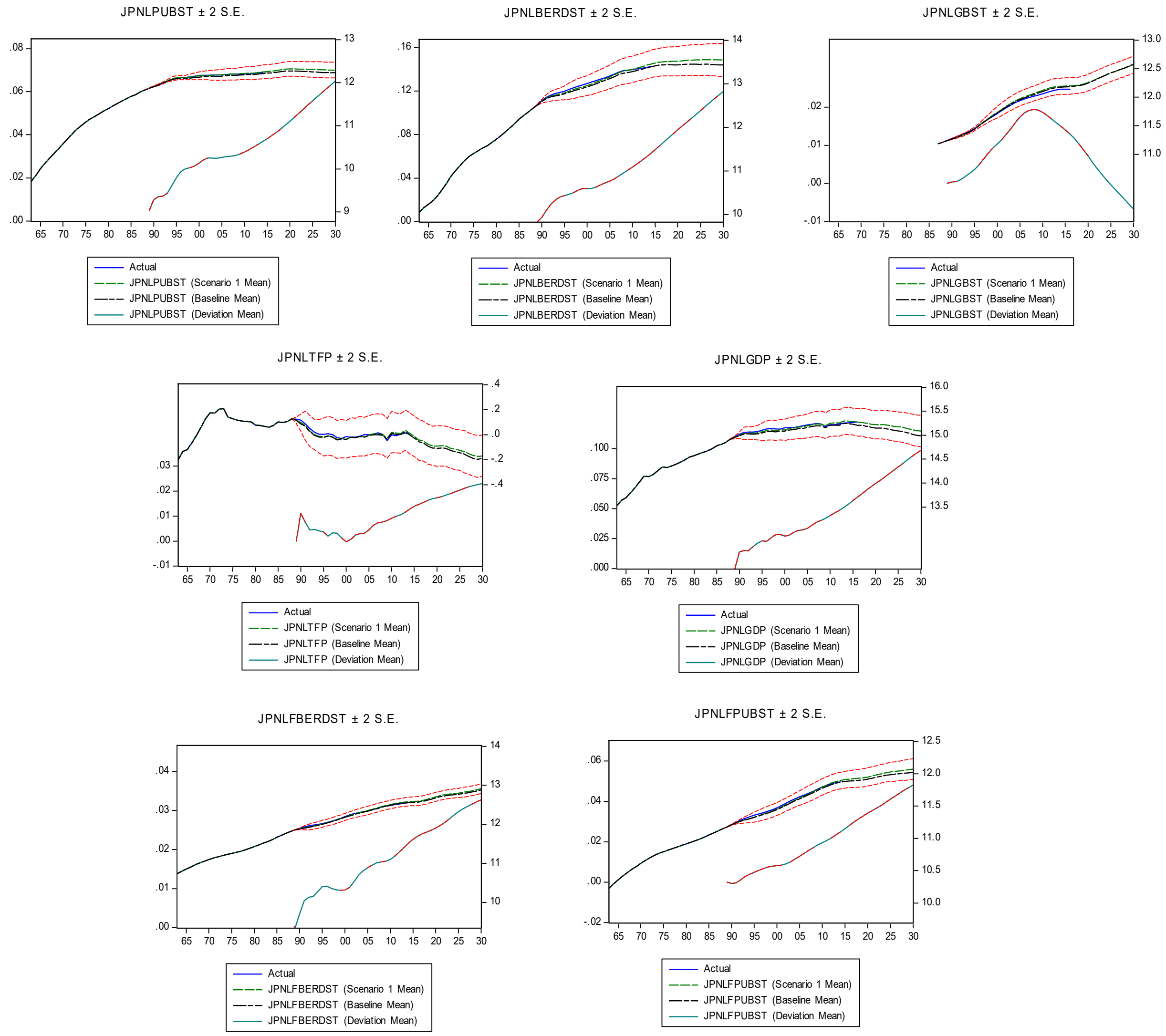

Figure 1 Effects of a permanent shock on public R&D stock until 2030. The left axes measure differences to baseline at the lower curve. The right-hand axes measure levels of scenario 1, baseline and actuals at the higher set of curves in each graph. Confidence intervals are for policy scenario 1. Their shift is roughly the same as that from baseline and therefore the lines are on each other.

Figure 1 shows that - after the shock on public investment indicated by the start above zero in the upper left graph - public R&D stock keeps growing. Private R&D, LBERDST, shows a similar pattern but a stronger change. GBAORD increases for 18 years but then returns to baseline. TFP increases slightly and GDP strongly, indicating that besides hiring wages increase when R&D expenditure increases. Foreign private R&D goes up, as does foreign public R&D; Japan creates positive spillovers for foreign private R&D for the model of this period. As Bernstein and Mohnen (1998) find no spillovers from Japan to the USA (for an earlier period though) and Luintel and Khan (2004) even negative ones, it is likely that Japan generates spillovers to or stimulates expenditures of the EU. This is in line with positive effects found by Luintel and Khan (2004) on other countries than the USA. But here it comes explicitly from public R&D shocks, which is in line with the finding of Luintel and Khan (2004) that business R&D has weaker effects than total R&D. Here, the effects are positive for TFP (with the exception of one year) but higher for GDP, meaning that R&D has other dynamic effects than just those via TFP, which may be wage increases through additional labour demand from higher R&D expenditures.

Figure 2 shows that after a shock on the intercept of the equation for GBAORD, indicated by the positive value in the middle-left graph, GBAORD (LGBST) goes up relative to baseline. Public R&D stocks are above baseline for almost ten years but then go below it. Private R&D stocks are below baseline throughout. One result therefore is that increasing GBAORD in Japan has a negative effect on private R&D. TFP is above baseline for one year only. The overall effect on GDP is positive only for three years. Japan's shock to GBAORD increases foreign private R&D also only for three years and foreign public R&D goes below baseline for the whole period until 2030. Overall, there are only very short periods of benefits from additional GBAORD in Japan.

Figure 3 shows that a permanent shock of 0.005 on private R&D has a positive effect on public R&D and a negative one on GBAORD. TFP and GDP react also strongly positively. Also foreign R&D variables react strongly.

Table 2 presents the average values of the differences for scenario and baseline for the years 1989-2030 for the plots of Figures 1, 2 and 3 all evaluated at expected values. The signs of the changes for GBAORD are opposite to those of private and public R&D, implying that an increase (decrease) of GBAORD may lead to a reduction (enhancement) of total R&D. The highest effect on TFP and GDP comes from a shock on private R&D. Effects on GDP are stronger than for TFP. This indicates that not only money goes into additional hiring but rather wages are also increased. Foreign private R&D reacts positively to all three shocks. With that exception, GBAORD generates negative reactions on all other variables. The opposite holds for public R&D, which enhances all variables.

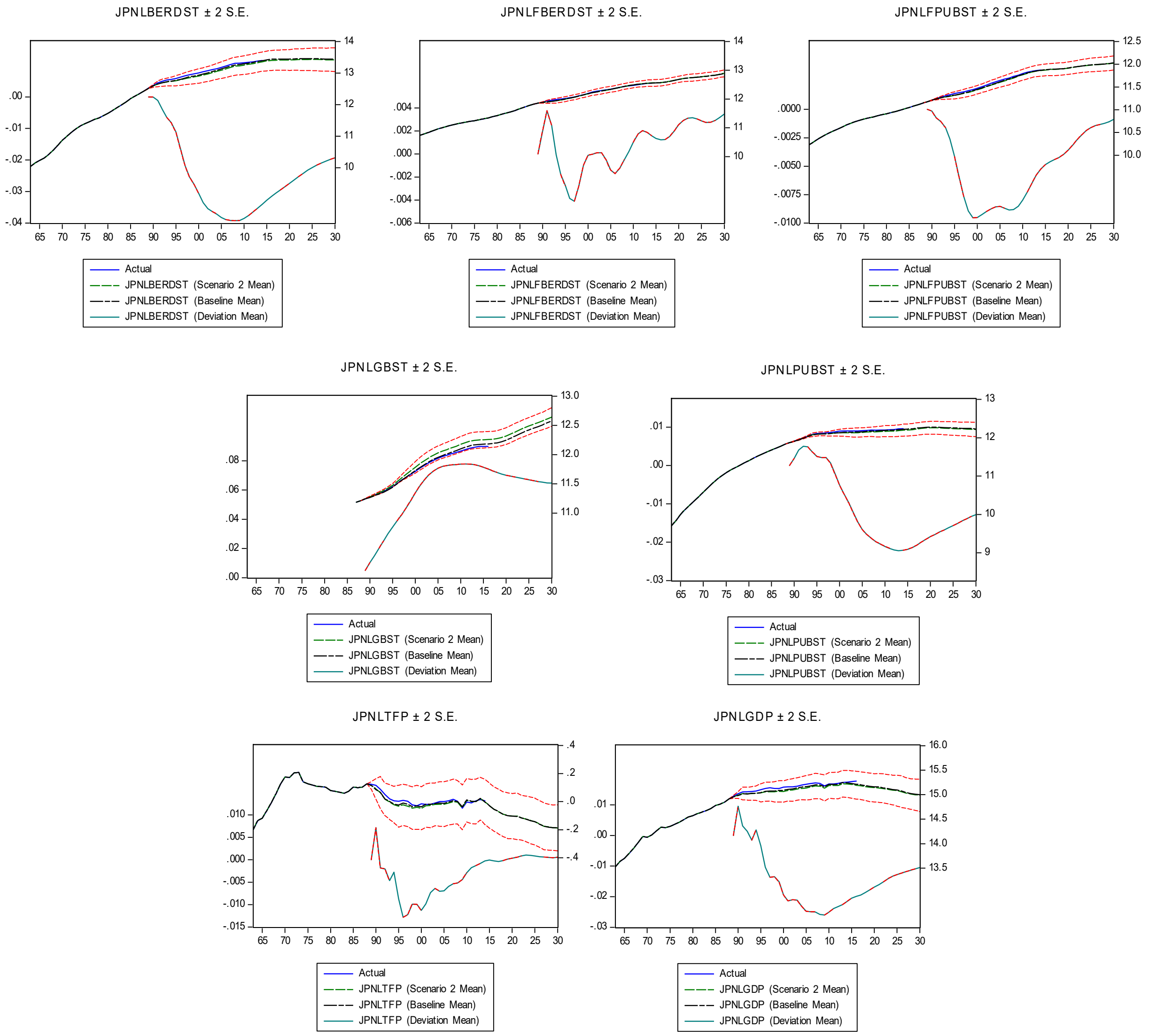

Figure 2 Effects of a permanent shock on GBAORD stock until 2030. The left axes measure differences to baseline by the lower curve. The right axes measure levels of scenario 2, baseline and actuals at the higher set of curves. Confidence intervals are for scenario 2. The difference from baseline and the shift of the confidence bounds are of almost identical magnitude and curves are lying seemingly on each other.

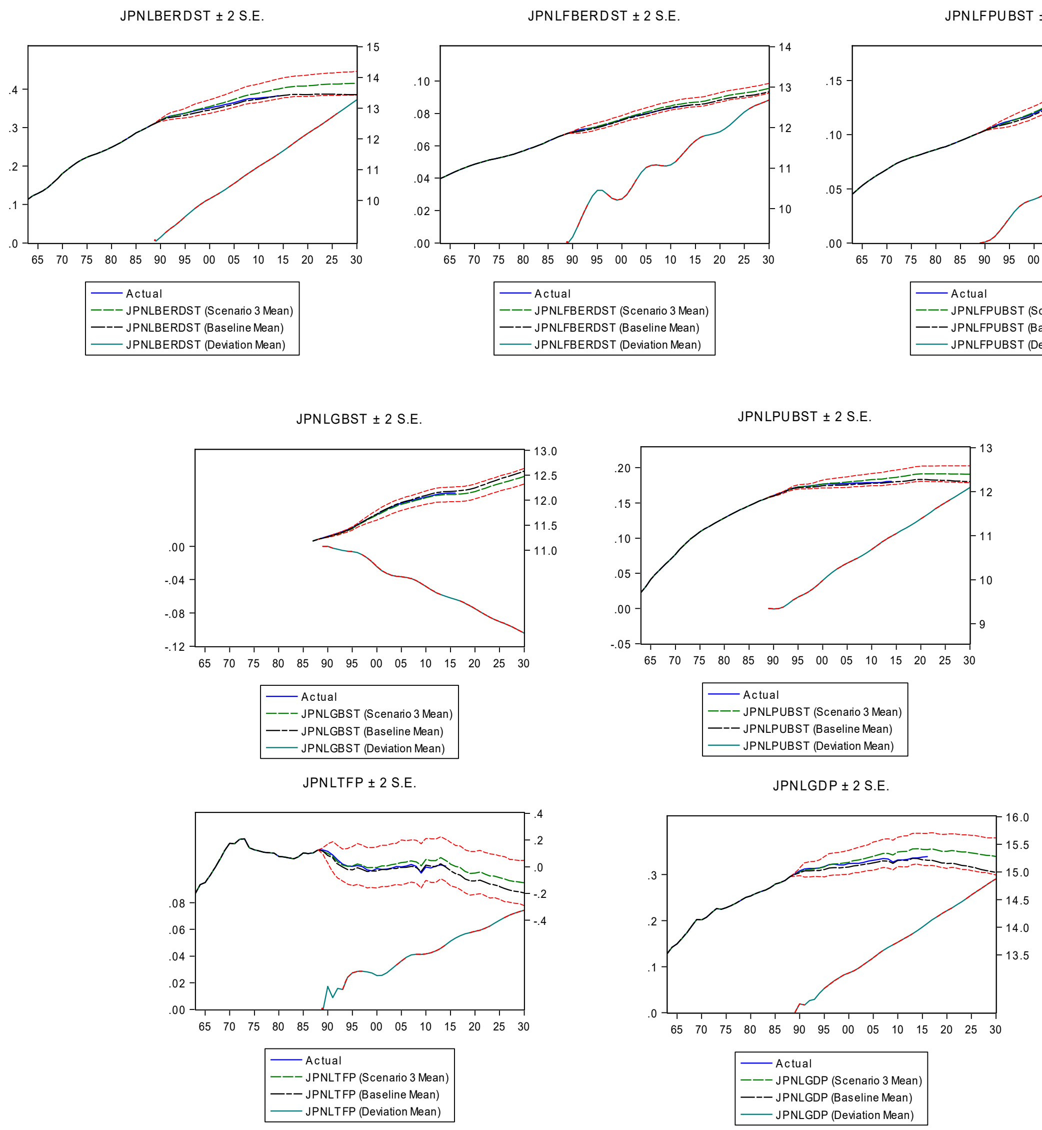

Figure 3 Effects of a permanent shock of 0.005 on private R&D stock until 2030. The left axes measure differences to baseline by the lower curve. The right-hand axes measure levels of scenario 3, baseline and actuals at the higher set of curves. Confidence intervals are for scenario 3. The difference from baseline and the shift of the confidence bounds are of almost identical magnitude and curves are lying seemingly on each other.

Table 2 Effects from shocks on public R&D, GBAORD, and private R&D: Percentage difference from baseline averaged from 1989-2030

Effects → From shock ↓	Domestic mission R&D (GBAORD)	Domestic Public R&D	Domestic private R&D	Foreign public R&D	Foreign private R&D	TFP	GDP
public R&D	0.008	0.035	0.06	0.02	0.018	0.01	0.0486
GBAORD	0.06	-0.12	-0.026	-0.005	0.0008	-0.003	-0.015
Private R&D	-0.048	0.08	0.19	0.07	0.05	0.043	0.15

Table 3 Net gains, DPV and internal rates of return (IRR) to additional public R&D, GBAORD, and private R&D

Shock	years of gains; average gain/GDP (a)	Sum DPV (4%) in bill. $	internal rate of return (payback period) (b)	remarks
public R&D	TFP:1990-2030; 0.008 GDP:1990-2030; 0.046	TFP: 454 GDP: 270.5	TFP:373 (2) GDP:396 (3)	Initial costs 0.5% of public R&D stock
GBAORD	TFP:1990-1992; 0.0035 GDP:1990-1996; 0.00033	TFP: -241 GDP: -953	TFP: neg (2;c) GDP:neg (2;c)	Initial costs 0.5% of GBAORD stock
private R&D	TFP: 1990-2030; 0.033 GDP:1990-2030; 0.14	TFP: 2122 GDP: 8109	TFP: 368 (4) GDP: 380 (4)	Initial costs 0.5% of private R&D stock

(a) 'TFP' indicates that only the yearly percentage share of TFP change multiplied to the GDP is counted as benefit. 'GDP' indicates that the yearly percentage share of the GDP change multiplied to the GDP is counted as benefit.
(b) Payback period is the number of years that it takes to have positive sum of gains after discounting at the internal rate of return. Period 1 is the shock period 1989.
(c) Negative sum of gains without discounting from periods 5 and 9 onwards, where project should be stopped; iir is zero or negative; payback period taken at zero discount.

Effects on TFP in Table 2 are strongly different on average. Moreover, if effects are positive they may still not justify the costs in terms of public and private R&D. This suggests comparing benefits and costs. Results may look better when limiting the evaluation - in a second step carried out in Table 3 - to periods of positive net gains from the policies shown in Figures 1, 2 and 3. Table 3 presents

- the years of positive gains,
- the results from calculating the gains (difference of shocks to baseline of GDP, minus change of cost flows for private and public R&D, including GBAORD) as share of GDP,
- their sum of present values discounted at 4%, and
- internal rates of return in two version explained in note (a).

The first row shows results for the permanent shock on public R&D compared to baseline, the second row for the shock on GBAORD compared to baseline, and the third row for the shock on private R&D. These are financial results comparing the policy shocks relative to baseline. Public and private R&D shocks have long-lasting gains until the horizon of 2030. In contrast, GBAORD shocks have a payback period one year after the shock but then run into losses after 5 years when only TFP gains are taken into account and after nine years when all effects on GDP are taken into account. GBAORD shocks have initial costs 0.005*GBST at 1989, where GBST is roughly half of PUBST; later costs are those of public and private R&D. The gains per year are larger for the private than the public shocks and very small for the GBAORD, where they are positive only because we average over the periods of positive gains and the initial period. The sum of present values discounted at 4% interest over all years has the same ranking: larger for the private then public shock, and negative for GBAORD. The internal rate of return is about equally high for private and public shocks on R&D; for shocks on GBAORD they are negative. The rates of return are higher for the GDP version than for TFP version of the gains (see note (a) of Table 3) suggesting that private and public R&D trigger more use of capital and employment, and higher wages. The rates of return for private and public R&D are higher than the marginal products of total R&D in the literature, which in turn was doing better than business R&D (Luintel and Khan 2004). The reason is that the traditional approach turns elasticities into a marginal product in an a-temporal way or as a steady-state solution of an error correction model. In our approach of calculating net gains per year and discounting them with the internal rate of return, it also plays a role whether the gains come about early or late. The high internal rates of return suggest that the gains are obtained early as indicated by the short payback period. Short but early periods of gains lead to high internal rates, and long periods with late gains can lead to high returns. Payback periods after discounting at the internal rate of return are inversely proportional to internal rates of return as indicated in the second but last column of Table 3. Comparing Figures 1, 2 and 3, Japan's increase of the ratio of GBAORD flows over GERD-BERD in Table 1 from 0.5 to unity seemingly is ensuing in terms of stocks from a policy of GBAORD shocks but not from a policy of shocks to public and private R&D. In our model, this goes together with negative effects on TFP and GDP over the longer period and only a short period of gains in the short run.

There are a couple of reasons why the rates of return are so high and payback periods so low. First, we do not take into account the additional costs for capital and labour in production of the higher GDP; it is exactly the purpose of growth policies to increase employment and wages and attract international capital. However, the effects not coming from TFP are not very strong in terms of internal rates of rerun differences. We do not include these indirect effects in the costs, which are not only costs for firms but also income for households, and therefore cancel from a welfare perspective. Second, the analysis is ex-post, whereas decisions are taken under uncertainty and risk; implicit risk premia may be high here. Third, a log-log specification as used here has decreasing marginal products in case of positive coefficients; by implication, rates of return may be higher if less has been done in terms of inputs. Fourth, policies affect international R&D, which generates spillover repercussions to the economy under consideration, which are predominantly positive.

Table 2 and Figures 1 and 3 indicate that foreign private and public R&D stock are endogenous for Japan, whereas Luintel and Khan (2004) find only a 9% probability for this when foreign R&D stock are built from the sum of private and public flows rather than having two foreign stocks, for private and public R&D separately. Defining foreign public and private R&D stocks separately in our paper makes the impact of Japan's innovation on foreign R&D visible.

6. Results for shocks to foreign public and private R&D shocks

As Luintel and Khan (2004), working with a similar method but leaning on long-term relations only, did not get clear results regarding foreign total R&D spillovers it may be worth investigating the question again, separately for foreign private and public spillovers, in the presence of a GBAORD variable, using the results from permanent shocks.

Figure 4 shows the effects of a shock on foreign private R&D stocks. All variables except for GBAORD go up for the whole period. The reaction of TFP is as small as the reactions of the foreign R&D variables. All other variables react more strongly. In particular, that of BERDST is much stronger.

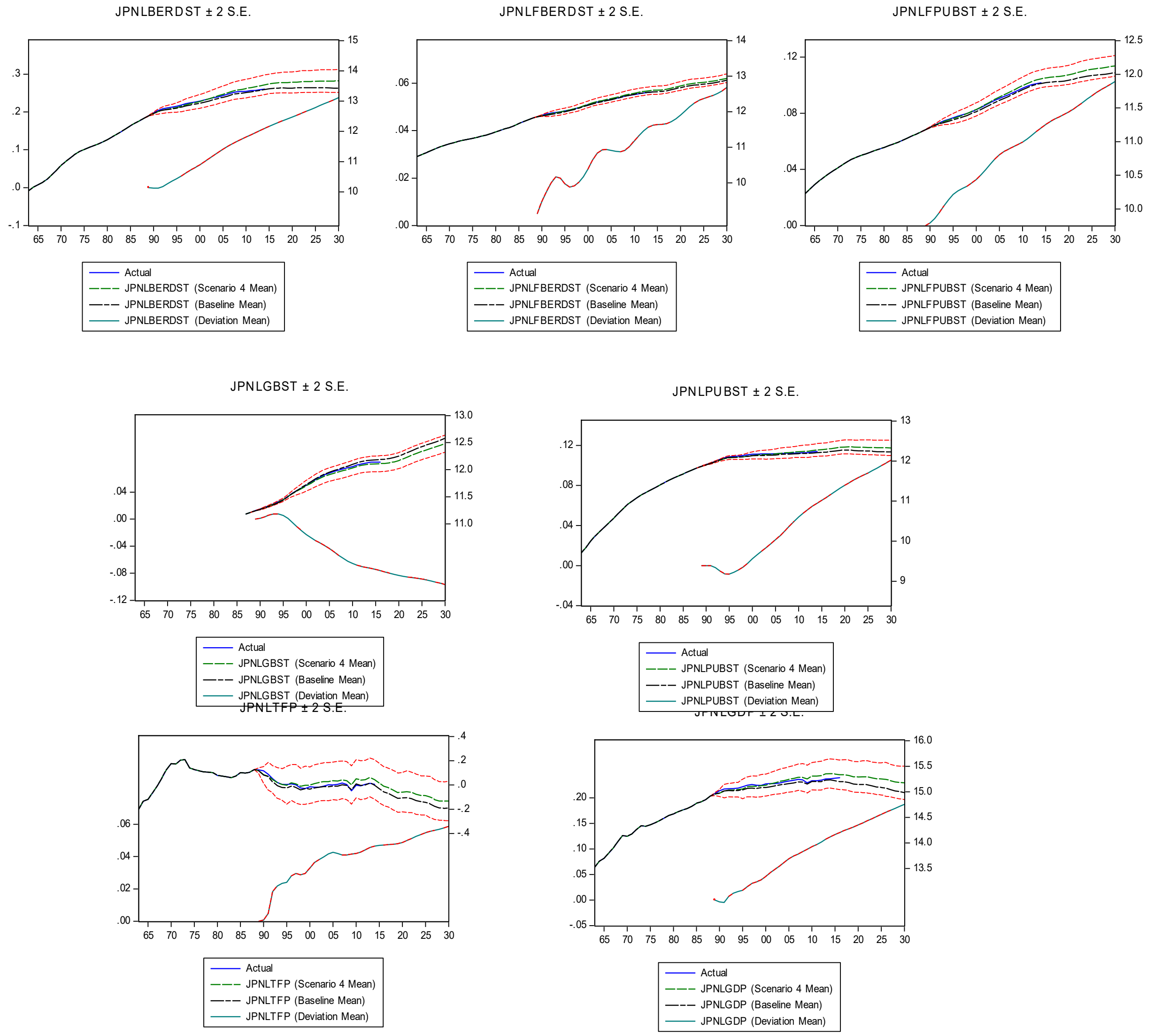

Figure 4 Effects of a shock to foreign private R&D stocks. The left axes measure differences to baseline at the lower curve. The right axes measures levels of the alternative scenario, baseline and actuals at the higher set of curves. Confidence intervals are for alternative scenario. They shift at an identical amount as the scenario relative to baseline and are hardly visible.

Figure 5 shows the effect of a shock on foreign public R&D. Again, GBAORD is the only variable that reacts negatively. Again, domestic private R&D increases most strongly, 2.5 percent per year. GBAORD clearly falls throughout. TFP goes up in the first period of five years. The reaction of GDP goes proportional to that of TFP and is stronger again than TFP.

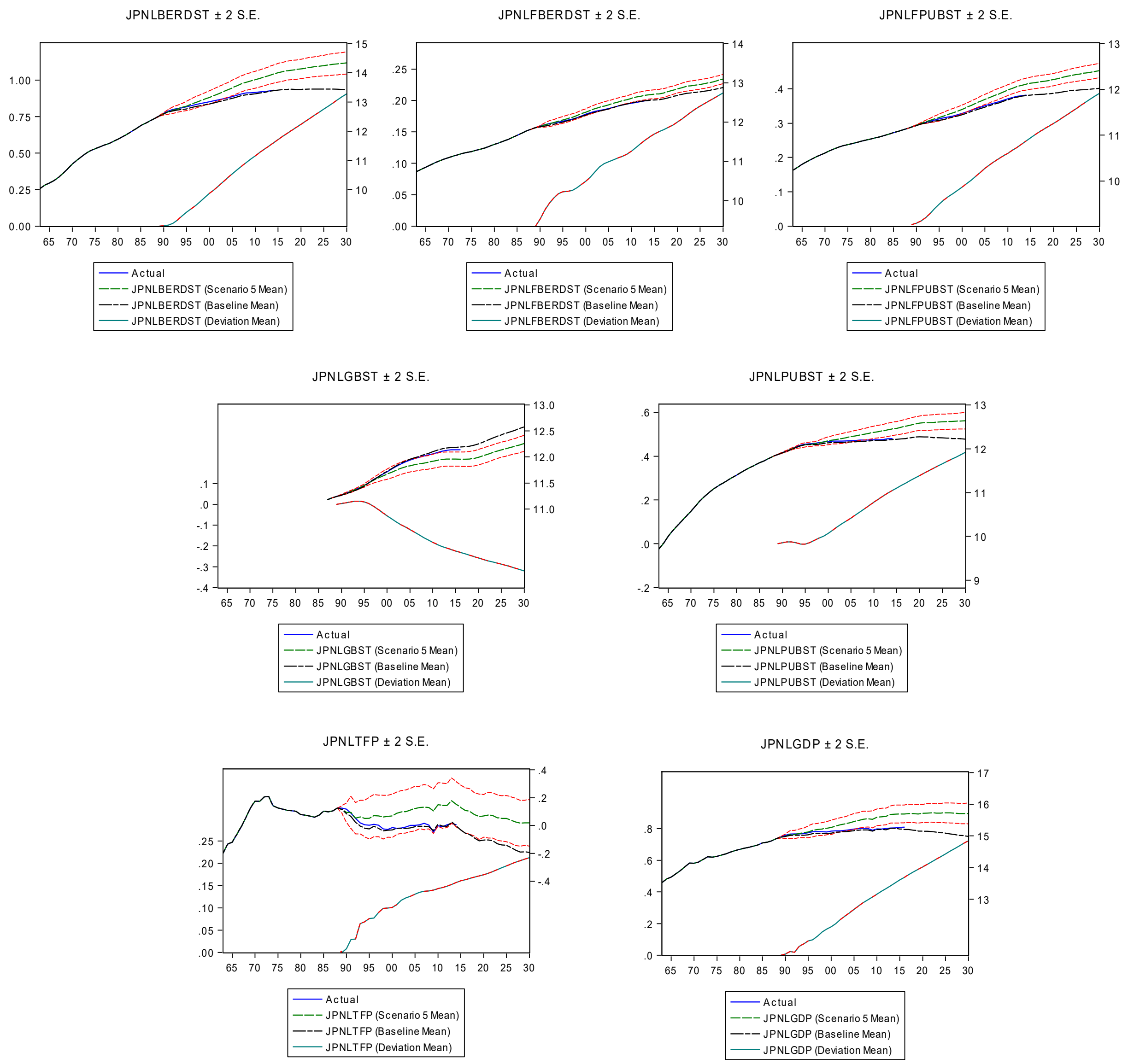

Figure 5 Effects of a shock to foreign public R&D stocks. The left axes measure differences to baseline at the lower curve. The right axes measure levels of the alternative scenario, baseline and actuals at the higher set of curves. Confidence intervals are for the alternative scenario. Those for the difference from baseline shift in proportion with the scenario.

In sum, foreign public and private R&D shocks both stimulate domestic private R&D, TFP and GDP together with all other variables except for GBAORD. Having foreign R&D stocks separately for private and public R&D variables, permanent shocks to them clearly play a role for private and public R&D in Japan. Together with the results from the previous section showing the impact of shocks in Japan on the foreign stock variables, this implies that Japan's R&D well integrated into the world economy; effects go both ways.

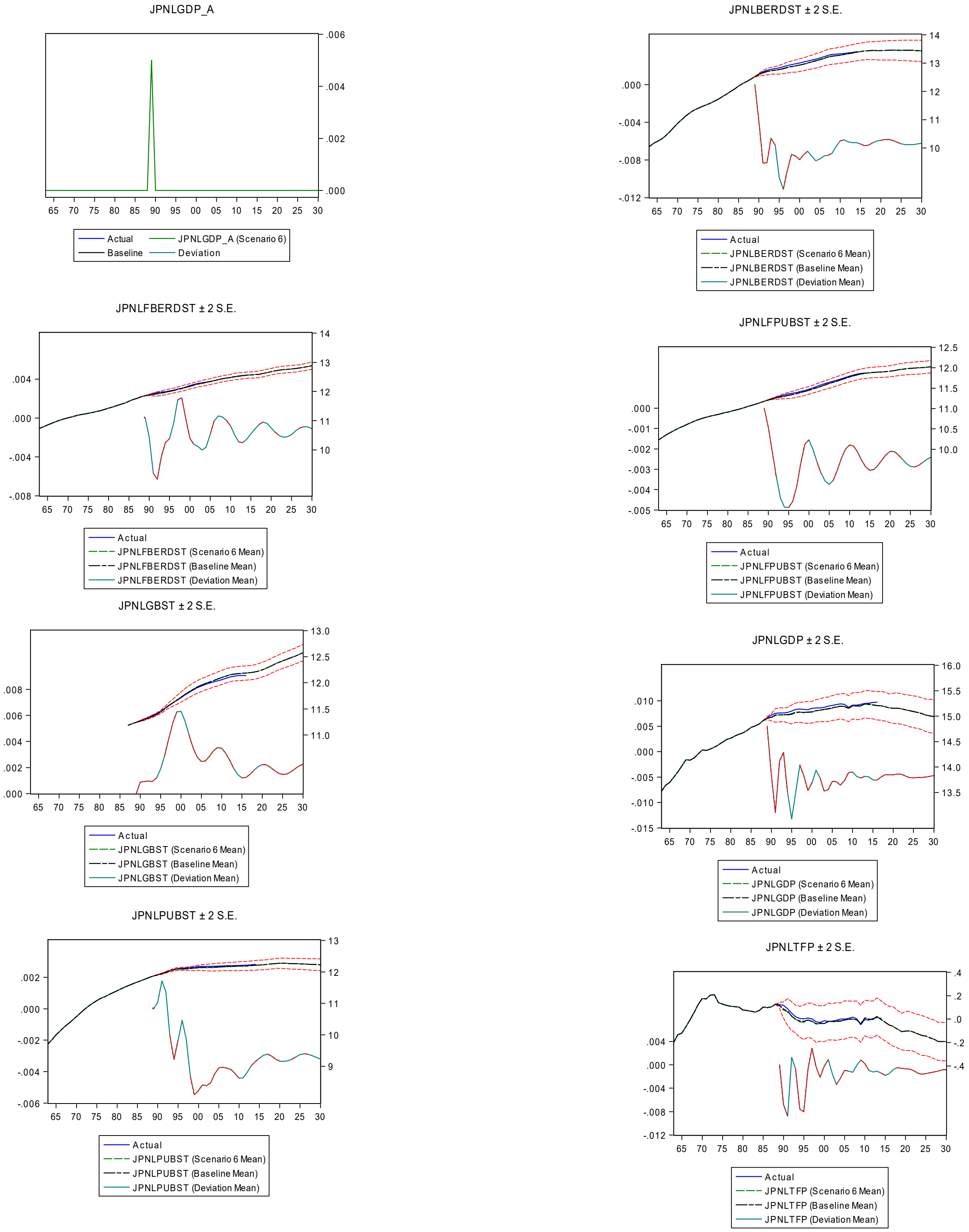

Figure 6 Effects of a transitory shock to GDP. The left-hand axes measure differences to baseline at the lower curve. The right axes measure levels of the alternative scenario, baseline and actuals are on by the higher set of curves. Confidence intervals are for the alternative scenario. Those for the difference from baseline shift in proportion with the scenario.

7. Checking cyclically of public R&D: The effects of transitory GDP shocks

A transitory shock to GDP in 1989 of 0.005 shown in the upper left graph of Figure 6 generates a positive reaction of GBAORD in the third graph from above in the left column of graphs of Figure 6. GBAORD reacts here like a pro-cyclical policy reaction functions. Public R&D reacts positively in the short run and negatively in the long run in the lower left graph of Figure 6. Therefore, a negative long-run effect complements the negative short run coefficient in our estimation result of equation (12); both are in line with Pellen et al (2017) up to the positive impact effect. In contrast, GBAORD is pro-cyclical. All other variables react with ups and downs to the positive GDP shock starting at least with negative reactions.

8. Summary and conclusion

We have shown that flows of GBAORD relative to public R&D have gone from 0.5 to unity over time for Japan. We have made GBAORD stock data and used them in a cointegrated VAR model.

Our VAR analysis has shown that public R&D affects business R&D, TFP, GDP and foreign R&D positively, in the short and the long run; the effect on GBAORD is only transitionally positive for 18 years and then goes back to baseline within another 16 years.

Shocks to GBAORD have positive effects only for a very short period and negative internal rates of return. The increase of GBAORD relative to public R&D indicated in Table 1 may therefore have reduced growth in Japan.

Additional private R&D in the form of a permanent shock has even better effects than public R&D. The net gains are strongly positive with high internal rates of return. Our recommendation as to ‘what policy changes would allow productivity to grow again’ (Hayashi and Prescott 2002) has two logical steps. First, as long as the causes for low TFP growth discussed in the literature continue to exist, we suggest a special form of an R&D policy. Private R&D shocks should lead the way and pull public R&D along, because the effect on public R&D and TFP is larger than from a shock on public R&D as can be seen from comparing Figures 1 and 3. Second, policy should reduce GBAORD by about ten percent over 40 years when R&D expenditure expands public and private R&D if the composition of GBAORD is left unchanged. Third, policy should improve upon the lack of human capital discussed in the literature if possible. Of course, analyses that are more detailed should identify needs for missions and their adjustments (Mazzucato 2018) and compare them to other suggestions, both of which are beyond the scope of this paper.

Additional private and public R&D has also had positive effects on foreign private and public R&D. In addition, we have shown that shocks to private and public R&D have positive effects on Japanese private and public R&D, TFP and GDP, but a negative one on GBAORD, where some of these effects have a short period of going into the opposite direction in Figures 4 and 5. Thus, it is hard to sustain that Japanese R&D has no effects on other countries' R&D decisions.

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Appendix Estimated VECM model

Abbreviations: LBERDST, LFBERDST, LPUBST, LFPUBST, LGDP, LTFP, LGBST are the natural logs of domestic and foreign private and public R&D stocks, Gross domestic product, total factor productivity, and GBAORD.

Model

Vector Error Correction Estimates
Sample (adjusted): 1989 2014
Included observations: 26 after adjustments
Standard errors below coefficients & t-statistics below standard errors
Cointegration Restrictions:
A(5,2)=0, A(7,4)=0, A(4,6)=0, A(3,4)=0, A(7,5)=0,B(1,1)=1, B(1,3)=0, B(1,4)=0, B(1,5)=0, B(1,6)=0, B(1,7)=0, B(2,1)=0, B(2,2)=1, B(2,4)=0, B(2,5)=0, B(2,6)=0, B(2,7)=0, B(3,1)=0,B(3,2)=0, B(3,3)=1, B(3,5)=0, B(3,6)=0, B(3,7)=0, B(4,1)=0, B(4,2)=0, B(4,3)=0, B(4,4)=1,B(4,6)=0, B(4,7)=0,B(5,1)=0, B(5,2)=0,B(5,3)=0, B(5,4)=0, B(5,5)=1,B(5,7)=0, B(6,1)=0, B(6,2)=0, B(6,3)=0, B(6,4)=0, B(6,5)=0, B(6,6)=1

Convergence achieved after 37 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 6):

Chi-square(5)	1.6112						
Probability	0.8999						
Cointegrating Eq:	CointEq1	CointEq2	CointEq3	CointEq4	CointEq5	CointEq6	
LGDP(-1)	1.000	0.000	0.000	0.000	0.000	0.000	
LTFP(-1)	-4.450 -0.085 [-52.31]	1.000	0.000	0.000	0.000	0.000	
LBERDST(-1)	0.000	-0.177 -0.004 [-49.80]	1.000	0.000	0.000	0.000	
LPUBST(-1)	0.000	0.000	-1.957 -0.017 [-113.29]	1.000	0.000	0.000	
LGBST(-1)	0.000	0.000	0.000	1.554 -0.005 [344.1]	1.000	0.000	
LFBERDST(-1)	0.000	0.000	0.000	0.000	1.534 -0.013 [121.6]	1.000	
LFPUBST(-1)	0.000	0.000	0.000	0.000	0.000	-0.521 -0.026 [-19.7]	
Trend (1963=1)	-0.017 -0.005 [-3.53]	0.008 -0.001 [7.60]	-0.013 -0.002 [-5.4]	-0.037 -0.011 [-3.32]	-0.059 -0.008 [-7.42]	-0.015 -0.001 [-11.38]	
C	-14.428	2.000	11.214	-28.902	-28.150	-5.631	
Error Correction:	D(LGDP)	D(LTFP)	D(LBERDST)	D(LPUBST)	D(LGBST)	D(LFBERDST)	D(LFPUBST)
CointEq1	-3.273	-1.877	-0.718	0.316	0.075	-0.328	-0.220

	-1.515	-1.250	-0.613	-0.307	-0.035	-0.243	-0.076
	-2.160	-1.501	-1.172	1.027	2.175	-1.352	-2.874
CointEq2	-14.163	-9.459	-2.517	1.172	0.000	-1.369	-0.865
	-6.314	-5.217	-2.554	-1.302	0.000	-0.995	-0.309
	-2.243	-1.813	-0.985	0.900	NA	-1.376	-2.798
CointEq3	-1.224	-1.274	-0.294	0.359	-0.174	0.074	-0.024
	-0.368	-0.279	-0.130	-0.080	-0.046	-0.070	-0.019
	-3.328	-4.563	-2.257	4.481	-3.765	1.051	-1.255
CointEq4	-1.019	-1.822	0.000	0.151	-0.239	0.367	0.000
	-0.561	-0.290	0.000	-0.202	-0.127	-0.143	0.000
	-1.816	-6.280	NA	0.747	-1.885	2.567	NA
CointEq5	1.745	2.795	0.056	-0.224	0.267	-0.433	0.000
	-0.794	-0.429	-0.072	-0.267	-0.173	-0.194	0.000
	2.199	6.510	0.776	-0.837	1.545	-2.234	NA
CointEq6	-3.375	-4.364	-0.380	0.000	-0.268	-0.483	0.266
	-1.505	-1.157	-0.541	0.000	-0.177	-0.273	-0.085
	-2.243	-3.773	-0.703	NA	-1.518	-1.766	3
D(LGDP(-1))	1.355	0.517	-0.045	-0.235	0.100	-0.068	0.033
	-1.457	-1.186	-0.600	-0.314	-0.140	-0.276	-0.102
	0.930	0.436	-0.075	-0.750	0.716	-0.246	0.328
D(LTFP(-1))	-0.751	0.066	0.059	0.179	0.003	0.158	0.008
	-1.090	-0.887	-0.449	-0.235	-0.105	-0.206	-0.076
	-0.688	0.075	0.132	0.762	0.032	0.765	0.103
D(LBERDST(-1))	2.535	3.031	0.805	-0.316	0.172	0.401	0.024
	-1.992	-1.621	-0.820	-0.429	-0.191	-0.377	-0.139
	1.272	1.870	0.982	-0.737	0.899	1.065	0.170
D(LPUBST(-1))	1.407	1.567	0.176	0.506	-0.029	0.478	-0.167
	-1.583	-1.288	-0.651	-0.341	-0.152	-0.299	-0.111
	0.889	1.217	0.270	1.486	-0.189	1.597	-1.511
D(LGBST(-1))	1.750	1.459	-0.065	0.359	0.179	0.259	-0.031
	-1.816	-1.478	-0.747	-0.391	-0.174	-0.343	-0.127
	0.964	0.987	-0.086	0.919	1.025	0.754	-0.242
D(LFBERDST(-1))	-0.054	0.198	0.017	0.320	0.100	1.176	0.073
	-1.249	-1.016	-0.514	-0.269	-0.120	-0.236	-0.087
	-0.044	0.195	0.034	1.192	0.833	4.978	0.836
D(LFPUBST(-1))	-0.171	-0.632	0.264	0.844	0.429	1.909	-0.132
	-5.694	-4.633	-2.343	-1.225	-0.547	-1.077	-0.398
	-0.030	-0.137	0.113	0.689	0.784	1.773	-0.331
C	-0.176	-0.185	-0.017	-0.018	0.011	-0.092	0.027
	-0.177	-0.144	-0.073	-0.038	-0.017	-0.033	-0.012
	-0.995	-1.287	-0.229	-0.470	0.642	-2.734	2.177
DUM96	-0.025	-0.025	-0.013	0.010	-0.011	0.002	0.001
	-0.036	-0.030	-0.015	-0.008	-0.004	-0.007	-0.003
	-0.679	-0.852	-0.855	1.212	-3.112	0.229	0.291
DUM08	0.028	0.013	0.020	0.008	-0.007	0.002	0.001
	-0.030	-0.024	-0.012	-0.006	-0.003	-0.006	-0.002
	0.932	0.546	1.635	1.310	-2.495	0.345	0.577

DUM13	-0.032	-0.019	0.003	-0.015	0.003	-0.004	0.005
	-0.028	-0.023	-0.012	-0.006	-0.003	-0.005	-0.002
	-1.119	-0.806	0.273	-2.454	1.265	-0.758	2.293
R-squared	0.816	0.844	0.965	0.984	0.995	0.960	0.990
Adj. R-squared	0.488	0.566	0.903	0.956	0.986	0.889	0.971
Sum sq. resids	0.002	0.001	0.00038	0.00010	0.00002	0.00008	0.00001
S.E. equation	0.016	0.013	0.006	0.003	0.002	0.003	0.001
F-statistic	2.490	3.036	15.560	34.854	111.730	13.490	53.205
Log likelihood	84.831	90.195	107.918	124.775	145.742	128.136	154.019
Akaike AIC	-5.218	-5.630	-6.994	-8.290	-9.903	-8.549	-10.540
Schwarz SC	-4.395	-4.808	-6.171	-7.468	-9.081	-7.726	-9.717
Mean dependent	0.013	-0.005	0.037	0.016	0.036	0.028	0.028
S.D. dependent	0.022	0.019	0.021	0.016	0.013	0.009	0.006

Determinant resid covariance (dof adj.)	1E-39
Determinant resid covariance	7E-43
Log likelihood	1002.9
Akaike information criterion	-64.3
Schwarz criterion	-56.22
Number of coefficients	167

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