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The economic footprint of the Dutch Research and Technology Organization TNO

Keywords: Economic footprint, Research & Development, Research and Technology Organisation, closed input-output analysis

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The economic footprint of the Dutch Research and Technology Organization TNO

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Abstract:

The role of Research and Technology Organizations (RTOs) in the society is to provide innovative products, services and production processes thus increasing productivity and enhancing the competitiveness of the economy. In this study, we have estimated the effect of subsidy given to the Dutch RTO TNO (the Netherlands Organisation for Applied Scientific Research). Such an assessment is relevant within the framework of a discussion on the role of RTOs in the economy and on effective and efficient policy interventions. The main result of the study is the estimation of the total effect of one euro spent on TNO subsidy. Macroeconomic theory stipulates that one euro spent on a specific product can lead to a rippling effects throughout the economy, resulting in more than one euro economic growth in total. This is called the multiplier effect and is caused by the respending of this euro by different agents. The analysis shows that one euro subsidy created a total increase of 1.88 euro of output which is higher than the sector average. We apply a closed input-output model in order to account for the respending of both the sectors as well as households.

JEL codes: D58, H59, O38

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1 Introduction

The role of Research and Technology Organizations (RTOs) in the society is to provide innovative products, services and production processes thus increasing productivity and enhancing the competitiveness of the economy. In this study, we have estimated the economic effect of subsidy given to the Dutch RTO TNO (the Netherlands Organisation for Applied Scientific Research). Such an assessment is relevant within the framework of a discussion on the role of RTOs in the economy and on effective and efficient policy interventions. Government intervention is justified due to the under-investment of R&D (Arrow, 1962). However, the effectiveness of governmental market intervention on R&D spending is a widely discussed topic in the literature. This study focuses on the public R&D spending through RTOs.

The impact of an RTO on the economy can be viewed two-way. One is the *economic footprint*, namely, how much the spending on the organization brings about the increase of output, income and wages in the whole economy. The other is the effect on productivity, competitiveness and technological level, also referred to as the *impact*. In this study, we are interested in the economic footprint. Macroeconomic theory stipulates that one euro spent on a specific product can lead to a rippling effects throughout the economy, resulting in more than one euro economic growth in total. This is called the multiplier effect and is caused by the respending of this euro by other agents.

There has been a number of studies concerning the *impacts* of public R&D expenditure and RTOs. Studies show that public R&D spending stimulates the business R&D spending. For every euro public government funding the business R&D expenditure goes up with up to one euro (Guellec & van Pottelsberghe de la Potterie, 2000; Hall & Van Reenen, 2000; Verhoeven, van Stel, & Timmermans, 2012). R&D tax credits also lead to additional innovation output of firms (Czarnitski et al., 2011). A Danish study found that companies using RTO R&D services were in fact 7.3 percent more productive than the companies in the control group (Forsknings- og Innovationsstyrelsen, 2011) However, another study found that public R&D expenditures do not automatically lead to productivity increase (van Elk et al., 2015).

Within the EARTO framework (European Association of RTOs), studies have estimated the *economic footprint* of European RTOs (Arnold, Clark, & Jávorka, 2010; Bilsen, Debergh, De Voldere, & Van Hoed, 2015). These studies have collected RTO specific data to estimate the footprints. The current study will go further in collecting RTO specific data on both inputs and outputs, in order to isolate fully the effect of the RTO. The analysis is applied on one RTO but this method can be applied on other RTOs and subsidy programs as well.

The main result of this study is the estimation of the total effect of one euro subsidy spent on the Dutch RTO TNO. This is one of the first estimations in the Netherlands at the level of detail of one RTO. Every euro of TNO subsidy creates a total increase of 1.88 euro of output through the rippling effect. This estimate refers to both the average and the marginal effect of the subsidy (which are equal by the choice of input-output analysis as the methodology for the study).

The next chapter describes methodology and data followed by a chapter with the presentation of the results. The main conclusions are described in the last chapter. A non-technical description of the study and its results can be found in the executive summary.

2 Methodology and data

Every euro spent on TNO increases the TNO output with the same amount. In order to produce one euro more output TNO will buy additional labour and the intermediate inputs such as computers or real estate. As a result, the sectors selling the intermediate inputs will have higher turnover and will also spend more on labour, capital and intermediate inputs including TNO research. In other words, these (backward) linkages depend on the demand for intermediate inputs and will therefore affect all related sectors.

To estimate this effect, we need data on all monetary demand and supply transactions in the Netherlands on a sectoral level. The national input-output tables provide these transactions among the productive sectors, households, external sector and the government. The input-output tables published by CBS have 76 different sectors including the sector called Research. For the purpose of this study, we would need a sector containing only the TNO organisation (which belongs to the sector Research) in order to isolate the effect of TNO from the rest of the Research sector. The sector Research was disaggregated into two sectors: “TNO” and “Other research”, using additional TNO data.

The national input-output table from 2014 was used in combination with two datasets from TNO. The first dataset contained all invoices received by TNO for the use of products and services. These data showed the suppliers to TNO, such as suppliers of computers, materials and real estate. The second dataset contained all research projects carried out by TNO for specific clients. These data provided information on the sectors that TNO sold to and includes clients such as industrial firms, other research companies and governmental institutes.

Other TNO data that has to be included in the table are value added and government subsidy. This data is available from annual reports. The government subsidy was considered as government final consumption (demand) in the input-output table. TNO is a state-owned entity and subsidies to state-owned entities should be considered as government final consumption. Hence, a demand-side input-output model is appropriate here.

The demand-side input-output model (or the Leontief inverse matrix) was then applied to the input-output table with 77 sectors to estimate the TNO multiplier. The multiplier showed the change in output of the whole economy resulting from the change in TNO subsidy. The total effect was decomposed into initial, direct, indirect and induced effect. The different types of effects are described below:

- The *initial* effect applies to a euro of government subsidy given to TNO.
- The *direct* effect applies to the spending of this euro by TNO on other productive sectors.
- The *indirect* effect applies to the respending of additional turnover by these other productive sectors and so on.
- The *induced* effect applies to the respending of additional wages by households.

The direct effect is expressed as the total amount spent on intermediate inputs per euro of TNO output. To calculate the direct effect the technical coefficients or direct requirements matrix is needed. Technical coefficients indicate how many cent worth of intermediate inputs are required from other sectors in order to produce a

euro of output. The matrix of the technical coefficients represents the sectoral production structure.

The indirect effect estimates the effect further upstream. To obtain the effect following the backward linkages, one would need to invert the matrix to obtain the Leontief inverse. The assumption is that in order to produce a product, a fixed amount of inputs from other sectors is required. The resulting direct plus indirect effect on the other sectors are expressed as *output* multipliers. The following equation represents the Leontief model.

$$X = (\mathrm{I} - A)^{-1} Y$$

Here X represents the n-dimensional vector of sector output, $(\mathrm{I} - A)^{-1}$ the Leontief inverse and Y -- the vectors of final demand by sector. The input-output model is commonly used to estimate the direct and indirect effect, as described above, and the output multipliers are a commonly used type of multiplier. However, in this model only the productive sectors are endogenous while the households are exogenous. Therefore the respending by households or the so called induced effect is not included.

However, a change in output not only has an effect on intermediate inputs but also on the wage bill. The additional wage bill or household income will be re-spent on the consumption of products leading to additional demand and eventually to additional output. Adding the induced effect to the direct and indirect effect will result in the *total* effect. Moreover, in this study it would be interesting to include the households as an endogenous agent because the additional stimulus of the wage bill will likely be large compared to the other effects. This is because TNO is a labour-intensive organization requiring many labour-intensive inputs that will significantly increase in the wage bill.

Households should be endogenized in order to estimate the induced effect. This is called closing the model with respect to households and is done with the inclusion of an additional row and column representing respectively household income and household consumption. Additional data from the national accounts is required to close the model, in particular data on household income other than labour income (e.g. social transfers) and income use other than consumption (e.g. savings). For this we followed the same procedure as described by Chen, Dietzenbacher, Los, & Yang (2010). The multipliers calculated with this closed input-output model will be higher than using an open model due to an additional agent that respends and are called *total* multipliers. The closed model is thus formulated as:

$$X = (\mathrm{I} - \overline{A})^{-1} Y$$

$$\overline{A} = \left[\begin{array}{c|c} A & H \\ \hline L & h \end{array}\right]$$

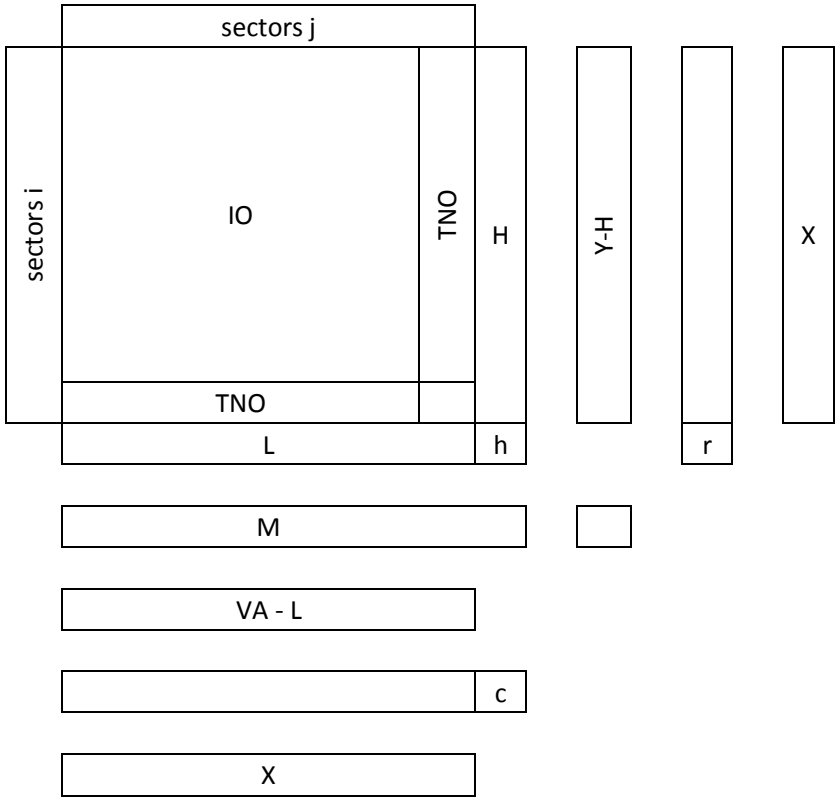
Here *X* represents output by sector, $(\mathrm{I} - \overline{A})^{-1}$ the input inverse from the closed input-output model, *Y* -- the final demand vector, $\overline{A}$ the technical coefficients from the closed input-output table, A the technical coefficients from the open input-output table, H household spending by product per euro of total household

income, L labour costs per euro of output by sector i and h labour costs paid by households per euro of total household income (e.g. domestic personnel). The model can be closed with other final consumers as well such as the government. However, households are typically the largest final demand category and are therefore most often endogenized in input-output models.

The changes in employment, GDP and tax revenue are calculated using fixed sectoral coefficients. These coefficients are respectively expressed as the number of employees per euro of output, GDP per euro of output and taxes per euro of output. Following the adjusted output levels from the direct, indirect and induced effects, the level of employment, GDP and tax revenues can be derived.

2.1 The input-output table

Figure 1: Overview of the input-output table extended with the TNO sector and closed with respect to households



IO	intermediate use by sector *i* to sector *j*
TNO	additionally created sector
L	labour costs by sector *j*
M	imports by sector *j*
VA-L	value added by sector *j* other than labour costs
X	output by sector *j*

H	household consumption by sector *i*
h	household consumption of labour
Y-H	final consumption by sector *i* other than household consumption
r	capital and property income, (foreign/social) transfers and other entitlements
c	income taxes, (foreign) transfers and savings
X	output by sector *i*

The figure above gives an overview of the main underlying data for the analysis, the input-output table. Each sector of the economy is represented by a row and a column in the table. The row provides information on the sales of the sector in question to all other sectors and, in addition, on the demand of final consumers (such as households, government, fixed asset formation and exports). Each column records the purchases of the sector from all other sectors (intermediate inputs), imports and the elements of the value added created in this sector (wages, gross margins, taxes). The input-output table was adjusted to fit the purpose of this study. Firstly, in order to obtain the multiplier effect of the TNO organization, a sector representing only the TNO organization was required. The input-output sector Research had to be split into "TNO" and "Other research". This disaggregation required microeconomic data from TNO.

Two microeconomic datasets were used. The first one contained all suppliers, from which TNO bought intermediate inputs. The invoices from these suppliers were aggregated to match the sector classification from the input-output table. This data is used to fill the column TNO, as shown in the figure above, and represents the use by TNO from sectors *i*. The second database contained all clients for which TNO provided research services. All research projects carried out for these clients were aggregated to match the sector classification of the table. This data is used to fill the row TNO, as shown in the figure, and represents the supply by TNO to sectors *j*. Labour costs data were taken from TNO annual reports.

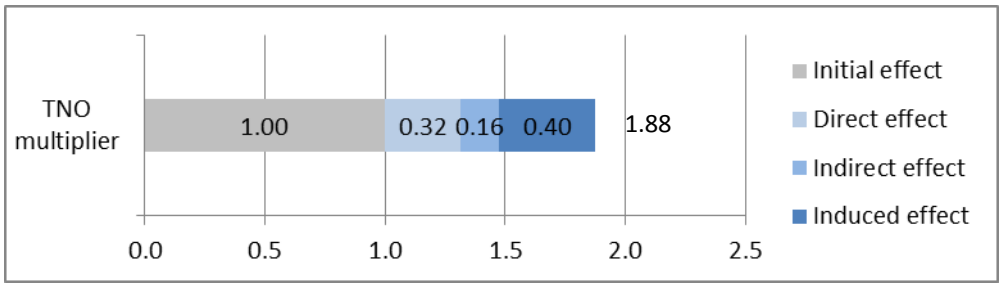
The second adjustment made to the input-output table is the closing with respect to households. This means that households are made endogenous in the model. We follow the procedure as described in Miller & Blair (1985) and Chen et al. (2010). The column *H* representing household consumption by sector *i* was taken from the exogenous final consumption block and added to the endogenous intermediate block. As a result, the intermediate block has an additional sector representing households consumption. However, household income is not only used for the consumption of goods but also for savings, (foreign) transfers and taxes. Therefore an additional row is added with the value c that represents the other uses of household income. For every column a row is required to balance it. To balance household spending, we require a row that represents household income. The row for labour costs is used for this purpose and it is extended with other sources of household income including capital and property income, profits, foreign or social transfers and changes in pension entitlements. The data was taken from the Dutch national accounts data.

3 The economic footprint of TNO

Our results show that the economic effect of each euro spent on TNO amounts to 1.88 euro in output in the Netherlands. This effect is higher compared to the effect of spending this euro on the average Dutch sector. This can be explained by the fact that TNO requires more labour-intensive inputs from other sectors, leading to the creation of high wage jobs. As a result the respending effect by employees/households is higher. The economic footprint of TNO is also higher compared to the rest of the research sector. This effect stems from the fact that TNO requires more material inputs from other sectors that generate rippling effects throughout the economy. The multiplier of 1.88 euro for every additional euro TNO subsidy corresponds to 1.15 euro in GDP value. Sectors that benefit indirectly from TNO are mainly business and public services and they account for 71 per cent of the additional output. According to our results, for every million euro spent on TNO 13.3 jobs are created.

This output multiplier of 1.88 euro can be further decomposed into the initial, direct, indirect and induced effect as illustrated in Figure 2. The initial effect simply refers to one euro government subsidy given to TNO. The direct effect amounts to 0.32 euro and refers to the spending by TNO on other sectors. For instance TNO would require to use more from the computer and real estate sectors. The indirect effect amounts to 0.16 euro and is the result of the respending by these sectors on other sectors. For instance the computer and real estate services in turn require to purchase extra intermediate goods. The induced effect amounts to 0.40 euro and reflects the effect of extra spending by households stemming from the increased wage bill.

Figure 2: Effect of one euro TNO subsidy on output, decomposed by initial, direct, indirect and induced effect



If we neglect the impact of the respending of the households in our analysis (as is often done in the input-output analysis literature), the resulting output multiplier will be indeed lower. It will amount to 1.48 euro for each euro spent on TNO and is comprised of 0.32 euro for the direct and 0.16 euro for the indirect effect. It will be somewhat lower compared to the multiplier for other sectors, which stands at 1.51. This small difference can be explained by a lower material content of TNO output in comparison with the rest of the economy. However, the total effect consists of the direct, indirect as well as the induced effect. We therefore believe that the model closed with respect to households yields an estimate of the multiplier which is more complete. Neglecting households in the model would be a diversion from the basic general equilibrium theory, which suggests that household incomes should be always accounted for in macroeconomic analysis

In addition to the output multiplier, the multipliers on employment, GDP and tax revenue were estimated and are summarized in Table 1. Every million euro subsidy given to TNO would result in 13.3 additionally created jobs. Seven jobs (7.1) are created within TNO while 6.2 are generated in other sectors, in particular in business services and the research related sectors “Other research” and “Education”. The GDP multiplier is estimated at 1.15 euro per one euro of TNO subsidy. Total tax revenues resulting from each euro TNO subsidy amounts to 0.28 euro. This means that more than a quarter of the subsidy flows back to the government through additional tax revenue.

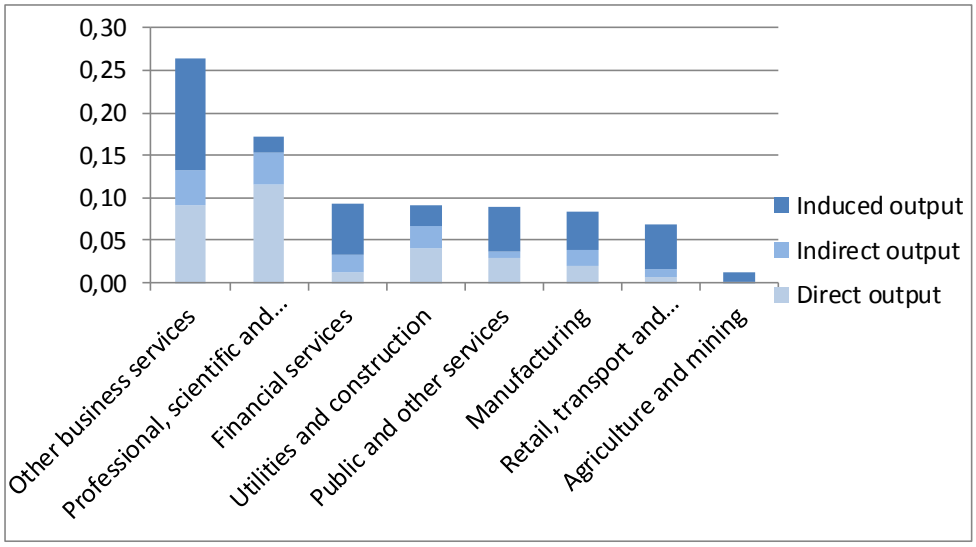
Table 1: Effect of each euro of TNO subsidy on employment, GDP and tax revenue

Jobs per million euro TNO subsidy	**GDP** per euro TNO subsidy	**Tax revenue** per euro TNO subsidy
13.34	1.15	0.28

Figure 3 decomposes the effect of TNO subsidy into effects enjoyed by individual sectors of the economy. The sector Professional, scientific and technical services benefits the most, as TNO uses most of its inputs form this sector. The sector Other business services is the close second and includes the intermediate consumption by TNO of IT, real estate and other business services. The induced effect (household spending) creates benefits that are more wide-spread across sectors compared to the spending of TNO. For instance, the induced benefit for the sector Retail, transport, hotels and restaurants mainly comes from the household spending effect rather than the TNO spending effect.

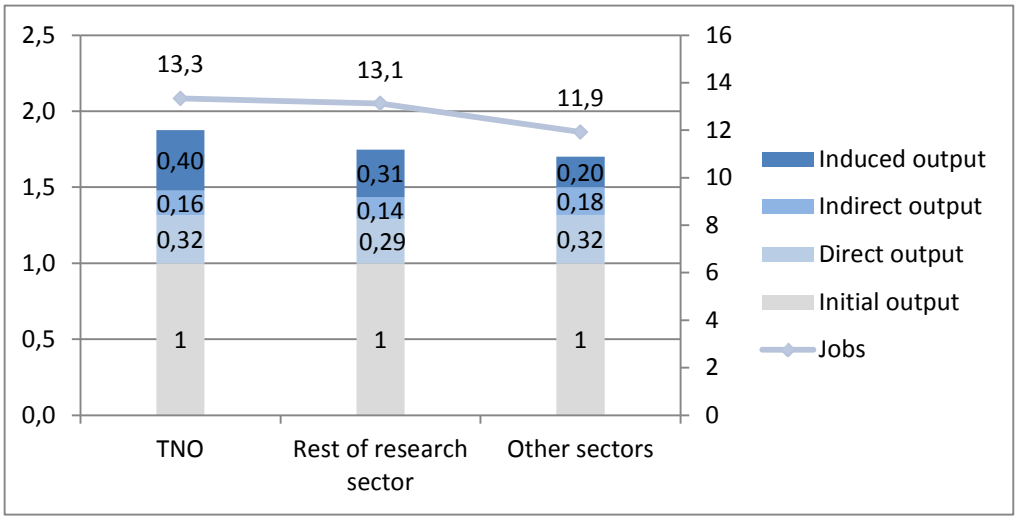
Note that the initial effect of one additional euro TNO subsidy is not included in the graph. The total effect including the initial effect would then indeed be by far the largest for the sector Professional, scientific and technical services which includes the TNO organization.

Figure 3: decomposes the total effect of TNO subsidy into effects enjoyed by individual sectors of the economy.



We then compare the effect of one additional euro spent on TNO with the effect of one additional euro spent on other sectors of the economy. Figure 4 demonstrates the total and decomposed effects of one euro spent on either TNO, rest of the sector "Research" or the other sectors. The effect of spending one euro subsidy on TNO is higher than the effect of spending one euro in the average Dutch sector or the research sector. The total output effects are 1.88 euro for TNO, 1.75 euro for the rest of the research sector and 1.70 euro for the other sectors of the economy. The direct effects are, respectively, 0.32, 0.29 and 0.32. The reason that the effect of a subsidy is higher in TNO than in the rest of the research sector lies in the fact that TNO uses more material inputs from other sectors. This is thanks to its laboratories and other technical testing facilities and also because inputs are used from the domestic market rather than from imports (higher direct effect). The induced effect (household spending) is 0.40 euro for TNO, 0.31 euro for other research and 0.20 for the rest of the economy. The reason that the effect of a subsidy is the highest in TNO stems from the fact that TNO requires more labour-intensive and research related inputs from other sectors. More high wage jobs are created indirectly by TNO as a result and thus more labour income is generated that can be respend by households (higher induced effect). It is noteworthy to mention that the TNO multiplier is higher than the other sectors only by including the respending effect of wages (induced effect), as TNO a labour-intensive organization requiring labour-intensive inputs.

Figure 4: Output and employment effect of one euro subsidy for TNO organization, rest of the research sector and other sectors, by direct, indirect and induced effect



4 Conclusions

In this study, we have estimated the effect of government subsidy given to the Dutch RTO TNO. Such an assessment is relevant within the framework of a discussion on the role of RTOs in the economy and on effective and efficient policy interventions. Our results show that a subsidy spent on TNO brings about more economic growth than if the subsidy had been spent on the national average sector. The effect of each euro spent on TNO amounts to 1.88 euro in output in the Netherlands. This effect is higher, compared to the effect of spending one euro on the average Dutch sector. This can be explained by the fact that TNO requires more labour-intensive related inputs from other Dutch sectors, leading to the creation of a higher wage bill (higher respending effect by households). The economic footprint of TNO is also slightly higher than in rest of the research sector. This is because TNO uses more domestic inputs from other sectors and, in addition, less imports.

The method that has been applied in this paper is useful for the evaluation of the TNO subsidy but can also be applied on other governmental subsidies spent on organizations. It can estimate the economic footprint of a subsidy and compare it with the footprint of other sectors, to show the effect had this subsidy been spent otherwise. The standard input-output model has been closed with endogenous households in order to capture better the effect on the wage bill. This is relevant in the case of evaluating subsidies that stimulate labour-intensive activities. Moreover, the TNO organization was introduced as an endogenous agent in the model that allowed for accurate estimation of the economic footprint of the TNO organisation.

The economic footprint captures the rippling effects through other sectors in the economy and is based on the notion that a euro subsidy given to one agent, leads to respending of the same euro by related agents. The economic footprint does not measure the positive long term effect of innovation on productivity, competitiveness and technical level. The mission of TNO is to stimulate and create innovation and therefore the effect of innovation should be taken into account as well when measuring the full impact of TNO. Therefore, further research on the impact of innovation through TNO on the Dutch economy is desirable. Such studies have been conducted for research in general but not yet for the TNO organization.

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Vitae

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