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Abstract

Commonly increases in total factor productivity (TFP) are associated with technological innovations measured by R&D expenditures. Empirical evidence seems to corroborate this relationship. However, in trading countries like the Netherlands, productivity increases, even in industry, can also be the result of innovations in the way transactions are managed. These innovations reduce transaction costs and exploit the welfare gains from (further) international division of labour. Such innovations are only partly included in R&D data. Consequently there is not much attention for these "trade innovations" – as we label them - in policy. In an empirical analysis this paper compares the influence of trade innovations with the influence of R&D expenditures on TFP in various industrialized countries. It appears that, at least in the Netherlands, trade innovations are as important for TFP as technological innovations which directly affect the efficiency of production, and which we label "product innovations".

Keywords: R&D, innovation, transaction costs, total factor productivity

JEL-codes: F10, F43, O47

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Frank A.G. den Butter and Paul Wit

Introduction

In modern growth theory productivity improvements are measured by the increase of total factor productivity (TFP). TFP forms the part in the increase of production in the production function that can not be explained by capital and labour inputs. Mostly innovations and technical change are thought of as contributors to TFP. Empirical research on productivity growth, thus, mainly focuses on R&D and human capital formation.

However, there exists an alternative for explaining productivity growth: transaction costs. Lowering these costs namely leads to further specialization and division of labour and consequently to productivity growth. Although most economists recognize the importance of transaction costs, there is not much empirical evidence in the literature on the contribution of innovations lowering transaction costs (which we label *trade innovations*) to TFP. Data on R&D only partly captures trade innovations and mainly measures innovations which directly enhance the efficiency of production (which we label *product innovations*). A reason that the contribution of trade innovations to TFP has not explicitly been studied, is that transaction costs and innovations lowering these costs are difficult to measure. This paper tries to deal with this measurement problem by using a proxy for trade innovations, namely the difference in the growth of trade (import and export) and growth of production. The implicit assumption is that without trade innovations, which lead to further specialization and division of labour, the growth of trade should be equal to the growth of production. We use this proxy in order to answer the following research questions: (i) How much do trade innovations and R&D contribute to total factor productivity? (ii) Are trade innovations contributing more to productivity than investments in R&D in the Netherlands? (iii) How much does the impact of R&D and trade innovations on productivity differ among countries? (iv) Should innovations lowering transaction costs be incorporated in the Lisbon Strategy?

The content of the paper are as follows. The next section shortly describes the concepts of total factor productivity, R&D expenditure and transactions costs from the perspectives of economic growth theory and transaction costs economics. It gives an overview of the existing empirical research on the impact of R&D and human capital formation on economic growth and productivity. Moreover some theoretical arguments are given for government intervention. Section 3 discusses the data and (simple) specification used in the empirical analysis. This analysis is presented in section 4. Firstly it focuses on the Netherlands because we expect trade innovations to play an important role in this country. The Netherlands is regarded as a ‘nation of traders’, where distribution, financing, marketing and services are important sectors in the economy (see e.g. WRR, 2003, Van Dalen and Van Vuuren, 2005). We conduct a co-integration and regression analysis on time-series data for the 1951-1992 period. After this, the contribution of R&D and trade innovations to TFP for six OECD-countries, namely France, Germany, Italy, the Netherlands, the United Kingdom and the United States, is estimated using time-series data for the 1983-2001 period. Section 5 concludes. Here we also look shortly at the implications of the analysis for the Lisbon Strategy. In the recommendations for economic growth this strategy mainly focuses on investments in R&D in order to enhance productivity (the 3% GDP target). When trade innovations play a major role, such as appears to be the case in the Netherlands, this focus is less warranted.

Innovation, growth and transaction costs

Total factor productivity and endogenous growth theory

In modern growth theory productivity improvements are measured by the increase of total factor productivity (TFP). It forms the part in the increase of production in the production function that can not be explained by capital and labour inputs, and covers many other, and sometimes unobserved determinants of productivity. It also includes measurement errors and aggregation bias. In empirical studies on TFP it is calculated by means of a growth accounting approach (see e.g. Timmer et al, 2003, Van Ark and De Jong, 1996 and Van Ark et al. 2002, Hulten, 2000).

Tinbergen already introduced the concepts of TFP and efficiency in 1942 and Solow provided a simple framework to measure TFP in 1957 (Tinbergen, 1942, Solow 1957). The neoclassical growth model, developed by Solow and Swan, forms the basis for the derivation of TFP. In this model technological progress i.e. productivity growth is assumed to be exogenous, in other words, technology is treated as ‘manna from heaven’. Yet, in order to understand and measure the influence of R&D expenditures on TFP it is warranted to endogenise technological progress and economic growth. An earlier strand to endogenous growth theory is the so-called ‘AK approach’, according to which technological knowledge is intellectual capital, which can be lumped together with computers, crankshafts, and other forms of capital into a single aggregate K (see Aghion and Howitt 1998). Seminal models of endogenous growth theory are given by Robert Lucas (1988) and Paul Romer (1986; 1990). As Romer (1994) points out, this new growth literature has been motivated by several issues: (i) a more satisfactory explanation of long run differences in performances of different countries, (ii) an attempt to explain aspects of the empirical puzzle not addressed by the neoclassical model, such as the importance of the Solow’s residual, (iii) a more central role for the accumulation of knowledge or the economy of ideas and (iv) a larger role for macroeconomics, e.g. fiscal and public policies, in explaining long run growth process (see OECD 2003, for a survey of endogenous growth theory)

Lucas (1988) incorporated human capital into the growth model. In this endogenous growth model, the level of output is a function of the stock of human capital. The accumulation of human capital will lead to a period of accelerate growth towards a new steady state growth path. Romer (1986; 1990) emphasized the importance of ‘new ideas’ for economic growth. In his model long run growth is primarily driven by the accumulation of knowledge. Here, new knowledge is assumed to be the product of a research technology that exhibits diminishing returns. He also assumes that the creation of knowledge by one firm has a positive external effect on the production of other firms. Spill-over effects are thus playing an important role in his model, which all together consists of three elements: externalities, increasing returns in the production of output, and decreasing returns in the production of new knowledge.

These 'new growth theories' have formed the basis of numerous empirical studies aimed at explaining economic growth and TFP. This research mainly follows two lines. The first line builds on the model of Romer and focuses on R&D. The second line explains growth through the accumulation of human capital and builds on the work of Lucas. As our empirical research is confined to the influence of R&D on TFP, we will not discuss human capital explanations for economic growth any further, albeit that what we call trade innovations is much related to investments in human capital.

Empirical research on the determinants of growth

Empirical studies on the impact of R&D on production include cross-section, time series and panel data analyses and use data on the level of the country, industry and firm. A survey by Cameron (1998) shows that most empirical studies find a strong relationship between R&D capital and production. The elasticities range from 0.6 to 0.42. So it seems that the magnitude of the impact of R&D on production is difficult to determine.

From a policy point of view the spill-overs from investments in new technologies are important as they are associated with (positive) externalities. It hinges on the assumption that technology developed elsewhere can, almost without costs, be implemented in ones own country or firm. CPB (2002) surveys research on these spill-overs and finds that spill-over effects (or indirect effects) are a major contributor to growth. On average, the indirect returns of R&D are 2,63 times the value of the direct returns of R&D.

With respect to the link between TFP growth and R&D spill-overs, Jacobs, Nahuis and Tang (2002) use sectoral data for the Netherlands. They find an elasticity of total factor productivity with respect to R&D of 37% for R&D conducted by the sector itself, of 15% for R&D conducted by other sectors in the Netherlands, and of almost 3% for R&D by foreign sectors. This emphasizes the importance of R&D spill-overs as both domestic R&D as well as foreign R&D have a significant impact on productivity growth. The impact of foreign R&D is, however, relatively small.

Guellec and van Pottlesberghe de le Potterie (2001) provide empirical evidence on a country level. Using panel data for 16 OECD countries, they find that R&D is important for productivity and economic growth, be it developed by business, by the public sector or coming from foreign sources. According to their estimates an increase of 1% in business R&D, foreign R&D and public R&D generates respectively 0.13%, 0,44% and 0.17% productivity growth. These outcomes are somewhat at variance with the results from Jacobs, Nahuis and Tang, who find a much smaller impact of foreign R&D.

Transaction costs economics and trade innovations

The main argument of this paper is that besides product and process innovations resulting from technology oriented R&D, innovations in trade can also lead to productivity growth.

The theoretical basis for this is provided by the economics of transaction costs. It shows that lowering transaction costs will lead to further specialization and division of labour, and therefore to productivity growth. As a matter of fact, when R&D data would include efforts to reduce transaction costs, an empirical analysis of the influence of R&D on productivity growth would automatically include the effect of trade innovations. However, as we will see, efforts to foster trade innovations are, for a large part, excluded from data on R&D.

Adam Smith already illustrated that specialization and division of labour increases productivity and therefore constitutes a major source of economic wealth. He was inspired by the idea that the price and market mechanism can 'freely' coordinate the division of labour. That there are costs involved in running the market mechanism has long been overlooked by economists. Finally it was Coase (1937) who noticed that if the market mechanism effectively allocates resources, there is no reason for resource allocation to be planned within the hierarchy of firms. He suggested that market allocation brings about costs, and that optimal firm size is determined by marginal costs of allocation through the market being equal to the marginal costs of allocation within the hierarchy.

The first author to use the term 'transaction costs' was Arrow (1969). He referred to transaction costs as the costs of running the economic system. A more detailed taxonomy of transaction costs is given by Williamson (1985). Williamson follows Arrow's definition of transaction costs and uses the economics of information as an important building block. He distinguishes between ex ante and ex post transaction costs. Drafting, negotiating and safeguarding an agreement are part of the ex ante transaction costs. The ex post transaction costs consist of the costs incurred when transaction drift out of alignment with requirements, the set up and running costs associated with the governance structures to which the disputes are referred and the bonding costs of effecting secure commitments (Dietrich, 1994).

Although Williamson focuses on the indirect costs of exchange, also direct costs are part of transaction costs. In this paper we define transaction costs as *all costs market participants make in exchanging goods, services and ideas*. Both traditional costs of trade transactions such as costs of transportation, taxes and tariffs, as well as more indirect costs as searching a potential trading partner, information costs about the reliability of the trading partner and the quality of the goods and services, the costs of negotiation and contracting, monitoring and enforcement costs, and also the legal infrastructure are part of transaction costs. Shortly said, transaction costs are all costs except the development and direct production costs.

In this vein North and Wallis (1994) make a distinction between transformation costs and transaction costs. Here, transformation costs are the costs of the land, labour, capital, and entrepreneurial skill required to physically transform inputs into outputs. Transaction costs are the costs of the land, labour, capital, and entrepreneurial skill required to *transfer property rights* from one person to another. Distinction between these costs is, however, difficult to make. They illustrate this by the following example. Hiring a foreman to supervise workers should be treated as a transaction cost, since it changes the property rights attached to the labour services by transferring the right to direct labour from the worker to the foreman, whereas in fact the foreman is typically treated as a cost of production.

Transaction costs, trade innovations and productivity

In the traditional trade theory trade is viewed as an allocation problem where transaction costs play a minor role (see Krugman and Obstfeld, 1997, for an overview of trade theories). However, there are significant costs involved in trading. These transaction costs, as specified above, have an important impact on the size of trade (Trefler, 1985) and set a limit to specialization and division of labour and therefore to productivity growth. Lowering these costs will thus enhance further specialization and division of labor and consequently productivity growth (see for example Amable, 2000, who shows that there is a positive relationship between specialization and productivity growth). In a theoretical exercise Herrendorf and Teixeira (2005) show how barriers to international trade, which can be considered to bring about high transaction costs, affect TFP in a negative sense.

Lowering transaction costs, which lead to an increased efficiency of trade can impact wealth in two different ways. The first extreme possibility is when traders (or intermediaries) have a monopoly position and trade margins stay the same. The welfare gains of the productivity growth will than solely benefit traders. In this case, the country that benefits is the home country of the traders. The other extreme possibility is that the trade margins will decrease with the same amount as the fall in transaction costs. In this case the increased efficiency of trade leads to an increase of trade because the price of goods and services lowers or the costs of producing can increase. It shows that there is a distribution problem associated with lower transaction costs: it can either accrue to the trader or intermediary, to the producer (producer surplus) or to the consumer (consumer surplus). The latter will occur in the case of a full competition equilibrium with costless entry of intermediaries

Innovations lowering transaction costs (trade innovations) result in productivity growth through further specialization and division of labour in the same way as discussed above. In fact, the use of an intermediary (lowering transaction costs) is an example of a trade innovation. Other examples of trade innovations are given in North (1997). He explores innovations that significantly lowered transaction costs and so lead to production and exchange that had not existed before. Three important trade innovations are mentioned. The first is the development of institutions that permitted anonymous exchange to take place across space and time. Among these institutions were intercommunity credit markets, insurance markets, contracts for future delivery, and the bill of exchange. Merchants gradually evolved codes of conduct (Law Merchant). In the absence of state enforcement, the basis of enforcement lied in reputation damage. As markets grew, this reputation mechanism was insufficient, which led to the second major trade innovation: the assumption by the state of the protection and enforcement of property rights. The third innovation is the realization of the gains from the modern revolution in science. Taking advantage of the 'marriage of science and technology' that led to new technology entailed an enormous reorganization of economies to realize the potential gains of this technology. It is necessary to have control over quality in the lengthening production chain and to have a solution to the problems of increasingly costly principal-agent relationships. Therefore institutional and organizational restructuring is essential to gain from technology. As North (1991) states: declining costs of transacting brought about by the innovations of institutions played a key role in the process of growth. It nicely illustrates the interaction between technological progress and innovations that reduce transaction costs.

Our concept of trade innovations is somewhat related to what Jacobs (1999) has labelled ‘transaction innovations”. In his view innovations do not only comprise product and process innovations, but also the mass customisation, i.e. the way products and services are sold. Examples the distribution of pizza’s and the leasing of cars and also airplanes.

The role of the government

North and Wallis (1982) emphasize that the government has an important role in reducing transaction costs. Their argument is that the state is not only concerned with transfer activities, but also must devise a set of rules to reduce transaction costs of the economic system in order to foster economic growth and expand the tax base and therefore income available for transfers. These transaction services reduce transaction costs and lead to further specialization and productivity growth. The fundamental argument is that, due to externalities, free rider problems and economies of scale, there is a market failure which the government has to repair.

Measuring transaction costs

Although lowering transaction costs can contribute significantly to productivity growth, the empirical proof is scarce. That is because transaction costs are difficult to measure. Many types of transaction costs are unobservable and cannot be quantified, for example search costs and risks. Wallis and North (1986) use the size of the transaction sector as their proxy for the aggregate size of transaction costs in the economy. The fundamental problem in using this proxy is that, on the one hand, division of labour gives rise to more exchange and hence brings about more transactions and more transaction costs. On the other hand, at the micro level it is desirable to minimize transaction costs. The rise of the transaction sector is exactly to serve that purpose (Wang 2003). Therefore using the size of the transaction sector as a measure for transaction costs can be misleading. This is especially true for a trading nation such as the Netherlands, which has a comparative advantage in keeping transaction costs low. A further problem here is come to an operational definition of the transaction sector. For instance, production and value creation of multinationals is, in the statistics, allotted to industry (the production sector), whereas, e.g. in the Netherlands, a large part of the activity of the multinationals relates to the orchestrating function of their headquarters. In fact this can be regarded as value creation through transactions.

If innovations lowering transaction costs were correctly measured in R&D figures, there would be no case to use a proxy for trade innovations. However, R&D figures are an inappropriate measure for innovations in transactions. Two points need to be made in this context. First, according to the present System of National Accounts (SNA-93) R&D is not considered to lead to the creation of intangible fixed assets. Second, following the Frascati Manual (OECD, 2002), the international guideline for measuring R&D, the main principle is that R&D leads either to pure knowledge creation or the initial conception of a product or process innovation. Here, the existence of exclusive ownership of knowledge is an important precondition for knowledge to comply with the general SNA definition of an asset (De Haan and Van Rooijen-Horsten 2004). The creation of general knowledge without exclusive ownership is thus not considered as an R&D activity. Remarkably this definition is even at variance with the argument of innovation policy that knowledge creation from R&D brings about positive externalities due to incomplete excludability, so that innovation policy has to repair this form of market failure. From the SNA definition of R&D it follows that knowledge about foreign markets that can lead to lower transaction costs is not included in R&D figures. Trade innovations of an institutional nature, such as the creation of a system of law, are also not captured in R&D. Finally, also research efforts which evoke trade innovations in the form of intangible assets are not part of R&D figures.

It shows that a large part of research efforts which lead to innovations lowering transaction costs are not correctly measured in R&D figures. These figures mainly focus on direct innovations in production, because of the compliance with the SNA definition of an asset in order to be captured in R&D figures. However, this does not mean that R&D figures do not measure any efforts to come to trade innovations at all. Some technological innovations included in R&D figures directly lead to lower transaction costs. The most obvious transaction costs that are lowered by technological innovations are transportation costs, for example by the creation of more efficient means of transportation. So although efforts to bring about trade innovations are not correctly measured in R&D figures, partially they are captured in R&D figures.

This study uses an alternative proxy to measure, at the macro level, what we call trade innovations. They contribute to a reduction of transaction costs at the micro level. So we try to circumvent the problems of the proxy by Wallis and North. Of course, we acknowledge that our proxy is a very rough measure of the underlying concept as well. The basis of our proxy is that the limits to trade are caused by transaction costs. Trade innovations are, through lower transaction costs, leading to further specialization and division of labour and consequently to an increase in trade. Here the amount of trade can be seen as a function of trade innovations and demand. Without trade innovations and thus further specialization and division of labour, the growth of trade should be equal to the growth of production, assuming a unit elasticity. Therefore we regard the difference between the growth of trade and the growth of production as a suitable measure for trade innovations and use it in our empirical analysis.

As already acknowledged, there are disadvantages of using this measure in estimating the (relative) contribution of trade innovations and R&D to TFP. In the first place, the difference between the growth of trade and the growth of production measures the effect of trade innovations on trade and specialization. It does not measure the total amount of expenditures on innovations lowering transaction costs (which may be subjected to diminishing returns). Consequently, by using this proxy nothing can be said about the effectiveness of investing in trade innovations. In the second place, the problem of reverse causality between trade innovations and productivity growth exists. Productivity increases due to better technologies may enhance specialisation as well and bring about more trade. Because of these opportunities for further growth and the limits to it placed by transaction costs, economic actors become more willing to invest in trade innovations to stimulate growth. Productivity growth can thus lead to more innovations in trade, just as innovations in trade lead to productivity growth. Finally, it should be noticed that an accurate distinction between innovations in production and trade innovations can not be made. Although R&D figures focus on innovations in production, they do, as mentioned before, partly measure trade innovations as well. When estimating the contribution of trade innovations and R&D to TFP simultaneously, the effect of some innovations in production that also lead to lowering transaction costs is now picked up by trade innovations and is no longer attributed to R&D. In our empirical analysis we try to avoid problems of simultaneity and of reverse causation by specifying lagged relationships.

Trade innovations and the Lisbon strategy
Governmental policy aimed at stimulating economic growth mainly focuses on knowledge (i.e. human capital formation) and research and development. One of the criteria of the Lisbon Strategy is that 3% of GDP must be invested in R&D. However, as previously explained, innovations in trade can also generate economic growth. The Lisbon Strategy should therefore also incorporate policies aimed at lowering transaction costs. Important policy issues for lowering transaction costs are education, infrastructure, better information and international cooperation. Some technological innovations indeed contribute to a reduction of transaction costs, e.g. developments in ICT which lowered search and information costs substantially. But a large part of innovations in trade remains unobserved and therefore unnoticed in policy. The Lisbon strategy also focuses on investments on R&D because these investments bring about large spill-overs between countries so that the EU-countries collect welfare gains from each others investments in R&D. That is why Gelauff and Lejour (2006), using an applied general equilibrium model for the world economy, find large positive effects for the EU when these countries would meet the target of 3% GDP. However, in their view investments in R&D mainly relate to product and process innovations so that possible positive externalities of trade innovations remain out of sight.

3. Data

In order to measure the influence of R&D and trade innovations on TFP, we have collected time series data on these variables In our empirical analysis we use two data sets. The first set consists of data on TFP, R&D and trade innovations for the 1950-1992 period for the Netherlands. The second set contains data on TFP, R&D and trade innovations for six OECD countries, namely France, Germany, Italy, the Netherlands, the United Kingdom and the United States, during the 1983-2001 period. As this latter observation period is rather short, we are obliged to estimate simple specifications in order to illustrate the differences among these countries.

TFP, R&D and trade innovations in the Netherlands in the period 1950-1992
For the measurement of our proxy for trade innovations, we use data on export, import and production form CBS Statline (Dutch Bureau of Statistics), the OECD economic outlook and the United Nations handbook of international trade and development statistics. Data on TFP and R&D for the 1950-1992 period are taken from Van Ark and De Jong (1996). (see the appendix for a more detailed description of our data sources) Unfortunately no comparable

data on TFP are available for a more recent period so that the first part of our empirical analysis does not take developments after 1992 into account,

Figure 1 shows the development of the annual growth rates of TFP, R&D and trade innovations, according to this data set. The growth rate of trade innovations seems to follow the growth rate of productivity quite good, with the exception of the first three years, and looks like a stationary process. On the other hand, the growth rate of investments in R&D is characterized by a strong negative trend until 1983.

Figure.1 Annual growth of TFP, R&D and trade innovations, in percentages

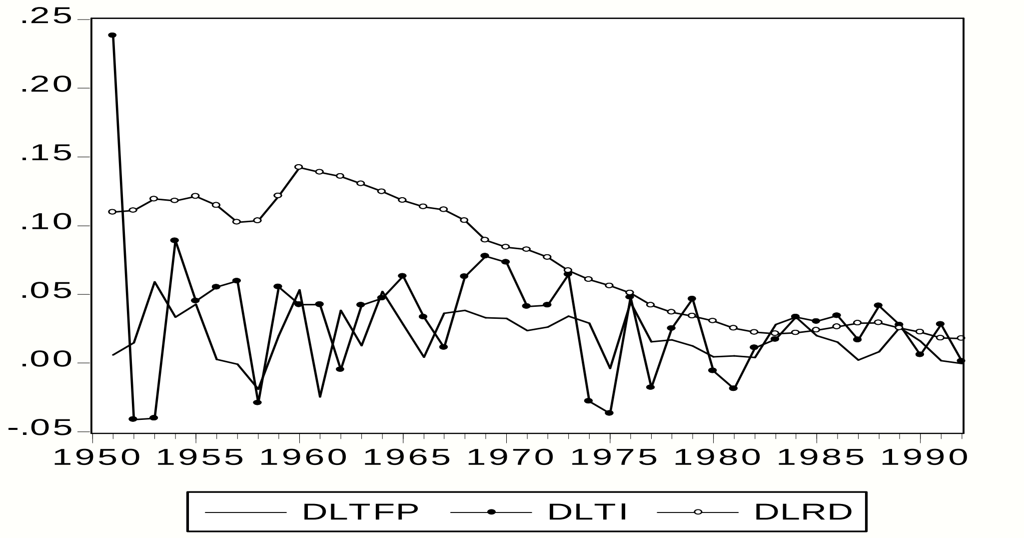

Table 1 Average annual growth of TFP, R&D and trade innovations, percentages

	TFP	**R&D**	**TI**
55-92	1,9	7,4	2,7
55-80	2,2	9,8	3,2
81-92	1,3	2,4	1,7
55-60	1,7	12,5	3,9
61-65	2,2	13,8	2,9
66-70	2,9	10,6	5,4
71-75	2,2	7,1	1,8
76-80	1,9	4	2
81-85	1,8	2,3	1,5
86-92	1	2,4	1,8

Table 1 summarizes the data set by giving average annual growth rates for various (sub)periods. The table shows that the growth of TFP is the highest during 1966-1970. During this period, the growth of trade innovations is also peaking. After 1970, the growth rate of TFP is declining to 1 percent a year. The growth in trade innovations and investments in R&D is also declining, but we note a small increase in the growth rate during the 1986-1992 period compared to the 1981-1985 period. The rapid decline of the growth rate of R&D after the 1961-1965 period is also noteworthy.

TFP, R&D and trade innovations in six OECD countries during the 1983-2001 period
For the international comparison we collected and constructed data on trade innovations from the OECD economic outlook. Data on TFP is found in the Total Economy Growth Accounting Database of the Groningen Growth & Development Centre (GDDC). Data on R&D expenditure are taken from the OECD Main Science and Technology Indicators Database. Table 2 shows the average annual growth rates of TFP, R&D and trade innovations of all six countries.

Table.2 Average annual growth rates, 1983-2001, percentages

	DE	**FR**	**IT**	**NL**	**UK**	**US**
TFP	1,7	0,7	0,8	0,8	1	0,9
RD	2,8	2,7	3,1	2,8	1,5	3,8
TI	2,6	3,4	3,4	2,9	3,0	4,2

Average growth rates of R&D and trade innovations do not seem to differ much with the exception of the UK. Germany witnessed the biggest growth of TFP, but does not have high growth of R&D and trade innovations compared to the other countries. The United States, according to these figures, is very innovative. They have a very high growth rate of both R&D and TI. This, however, does not yield a high productivity growth.

4. Empirical Analysis

Specification
Most empirical analyses of productivity, and more specifically TFP, use a simple Cobb-Douglas production function. Determinants of productivity are either investigated directly, by additional explanatory variables in a specification which explains (total) production, or in a two step procedure, where in the first step TFP is derived as unexplained part of a standard production function, and where in the second step TFP is explained by additional determinants. Our empirical analysis follows the two step procedure. For the first step we take TFP data from the literature (see the previous section) so that our analysis concentrates on the second step, namely explaining TFP. We do not specify a fully fledged model which encompasses the influence of both product and trade innovations, but just perform a simple time series analysis where we look at the relative explanatory power of R&D expenditure and (our proxy for) trade innovations on TFP.

In our analysis we use two specifications. Firstly we have the level of TFP explained by the level of the explanatory variables:

(1) $$\ln TFP_t = \beta_0 + \beta_1 \ln RD_{t-1} + \beta_2 \ln TI_t + \beta_3 \ln TI_{t-1} + \varepsilon_t ,$$

where TFP, RD, and TI are respectively total factor productivity, research and development, and trade innovations

The above specification conforms the Cobb-Douglas equation where TFP as the residual from the production function is explained by variables which represent induced technical progress. However, when measured in levels all variables in the equation show a strong trend. Therefore much of the correlation in (1) is trend correlation and the specification represents the long term relationship. As an alternative we specified a relation in growth rates:

$$(2) \qquad \dot{TFP}_{it} = \beta_{TI}\, \dot{TI}_{it-1} + \beta_{RD}\, \dot{RD}_{it-1} + \varepsilon_{it},$$

where a dot indicates the change in percentages. This relation can be seen as a short run relationship and does not suffer from trend correlation. In our analysis of TFP in the Netherlands we use both specifications, but for the regressions for the other OECD countries only specification (2) is used. Here i stands for the country in the regression.

5.2 Co-integration analysis for the Netherlands

In order to gain more insight into the time series properties of the variables of our regressions, we have tested whether the series for the Netherlands are co-integrated and have common trends. We used the so-called Engle-Granger (EG) method for this test. The first step is to determine the order of integration of the variables which we did by means of the Augmented Dickey-Fuller (ADF) test. The result are shown in table 3.

Table 3 Order of integration

	LTFP			LTI			LRD		
	I(0)	*I(1)*	*I(2)*	*I(0)*	*I(1)*	*I(2)*	*I(0)*	*I(1)*	*I(2)*
t-Statistic	-1,33	-6,17		-2,29	-9,58		-2,45	-0,63	-3,54
Critical Value 5%	-2,94	-2,94		-2,94	-2,94		-2,94	-2,94	-2,94
Order of integration		*I(1)*			*I(1)*				*I(2)*

The table shows that TFP and trade innovations are integrated in the first order. However, data on R&D pose a problem as they seem to be integrated in the second order. An eyeball test of figure 1 would confirm that the growth rates of R&D do not follow a stationary process. It implies that there can be no co-integration between TFP en R&D expenditure, and consequently from this empirical perspective, a relationship between R&D expenditure and TFP is hard to establish.

In order to find out about the co-integration between our measure of trade innovations and TFP, we performed the ADF unit root test on the residuals of the static equation:

$\ln TFP_t = \beta_0 + \ln TI_t + \varepsilon_t$

The t-statistic of -3,56 indicates that TFP and trade innovations are co-integrated indeed so that here a long-run equilibrium exists. The fact that TFP and R&D expenditures are not co-integrated, but that TFP and trade innovations are co-integrated, strengthens our a priori belief, that innovations in the transaction sector can be an important source of productivity growth in trading countries like the Netherlands.

The contribution of trade innovations and R&D to productivity
Now we come to our empirical investigation of the impact of trade innovations and R&D on TFP in the Netherlands. The results of 5 variants of specification (1) are shown in table 4.

Table 4 The contribution of trade innovations and R&D in the Netherlands, 1951-1992.

Dependent variable: LTFP

	(1)	(2)	(3)	(4)	(5)
LTI	0,69*			0,42*	0,47*
	(38,25)			(2,94)	(3,01)
LTI(-1)		0,68*		0,28*	0,32*
		(37,81)		(2,02)	(2,18)
LRD(-1)			0,26*		-0,04
			(28,56)		(-0,82)
C	1,33*	1,40*	3,38*	1,29*	1,00*
	(13,58)	(14,35)	(56,43)	(13,37)	(2,74)
Estimator	OLS	OLS	OLS	OLS	OLS
Period	50-92	51-92	51-92	51-92	51-92
No of obs.	43	42	42	42	42
R^2	0.97	0.97	0.95	0.98	0.98

* is significant at 5 percent level.

This table shows that during this reference period the contribution of trade innovations to TFP has been somewhat more substantial than the contribution of R&D expenditures to TFP. This is clear when comparing columns (2) and (3) with lagged values of both alternatives so that there are no problems with simultaneity and reverse causality. When R&D expenditure is added to a specification with both the contemporary and lagged values of trade innovations as explanatory variables (column (5)), R&D expenditures has no additional explanatory power.

Table 5 presents the estimation results for specification (2) with growth rates when using the long time series data set for the Netherlands. Now we have split up the observation period in some sub periods.

Table 5 The contribution of R&D growth and growth of trade innovations in the Netherlands

Dependent variable: DLTFP

	Period: 1955-1980			**Period: 1981-1992**			**Period: 1987-1992**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DLTI(-1)	0.35*		0.08	0.55*		0.32	0.46*		0.42
	(3.61)		(0.66)	(3.67)		(1.81)	(4.17)		(1.89)
DLRD(-1)		0.20*	0.17*		0.52*	0.32		0.38*	0.04
		(5.00)	(2.86)		(3.79)	(1.94)		(2.64)	(0.19)
Estimator	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
No of obs.	26	26	26	12	12	12	6	6	6

* is significant at the 5 percent level

The results in table 5 indicate that there has been a shift of importance between both explanatory variables during the reference period. In the first sub period, 1955-1980, R&D expenditures have the better explanatory power as measured by the t-values. When both variables are taken together in the specification, the coefficient and t-value of trade innovations become small (column (3)). In the second sub period, 1981-1992, the sizes are about equal, whereas in the third sub period, 1987-1992, the influence of trade innovations seems to dominate.

The overall conclusion is that trade innovations are an important contributor to productivity in the Netherlands. The empirical evidence also suggest that the relative contribution of trade innovations compared to innovations measured by R&D is increasing over time.

Differences in the contribution of trade innovations and R&D among countries
One criticism on the Lisbon strategy is the ‘one size fits all’ approach. All countries, according to this strategy, should invest at least 3% of GDP on R&D. As mentioned before, not all EU countries can be characterized as typical production countries. Some countries are more focused on distribution, financing, marketing and service. Our proposition is that in these ‘trading nations’, investing in R&D expenditures (as they are measured in the national accounting framework) may be of less importance than in countries where production technology matters more.

In order to test this proposition, table 6 gives the estimation results of specification (2) for six OECD countries, namely France, Germany, Italy, the Netherlands, the United Kingdom and the United States. The reference period now is 1983-2001.

Table 6 The contribution of R&D and trade innovations to TFP in six OECD countries
(t values in parentheses)

Dependent variable: TFP Growth

	FR	GER	IT	NL	UK	US
Growth_TI(-1)	0,10	0,17	0,00	0,17	0,12	-0,04
	(1,98)	(1,77)	(-0,03)	(1,55)	(1,18)	(-0,62)
Growth_RD(-1)	0,09	0,19	0,05	0,05	0,07	0,20
	(1,54)	(1,49)	(0,72)	(0,60)	(0,55)	(3,13)*
Estimator	OLS	OLS	OLS	OLS	OLS	OLS
Period	83-01	83-01	83-01	84-01	84-01	83-01
No. of obs.	19	19	19	18	18	19

* is significant at 5 percent level.

In the regressions of table 6 we have included both measures for innovations in each equation. It corroborates our previous result that in this period trade innovations have more explanatory power in explaining TFP growth in the Netherlands than R&D expenditures, albeit that the statistical significance of the coefficient values is rather low. In Germany and France the contribution of R&D expenditures is larger than in the Netherlands, while, quite surprisingly, the contribution of trade innovations is also substantial. The results for the UK are rather puzzling whereas trade innovations seem to have no impact at all in Italy and the US. The contribution of R&D expenditure to TFP is highest in the US and its coefficient is highly significant. All in all, even at the aggregated level, these result clearly show the differences between countries which are innovative in trade and countries which are innovative in production. Consequently, the 'one size fits all' approach of the Lisbon strategy and the focus on R&D expenditures for enhancing growth and the competitive position does not seem justified.

5 Conclusions

With respect to the 4 research questions in the introduction, the empirical analysis of this paper provides the following answers: (i) trade innovations contribute considerably to productivity in the Netherlands; (ii) nowadays trade innovations seem to contribute more to productivity than investments in R&D in the Netherlands (iii) the impact of R&D and trade innovations on productivity differs among OECD countries: we can see a clear difference of the impact of R&D expenditure on productivity between countries with large transaction sectors ("trading countries") and countries with a large production sector; (iv) it suggests that innovations lowering transaction costs should be incorporated in the Lisbon Strategy, or at least that the exclusive focus of the Lisbon criteria on R&D expenditure (the 3% GDP target) is unwarranted.

We acknowledge that this paper provides only a first attempt to separate the influence of product and trade innovations on productivity. It leaves much scope for future research. First, the proxy that is used to measure transaction costs, measures the effect of lowering transaction costs and not the expenditures on innovations lowering these costs. Here using an adequate data set with longitudinal data at the plant level is warranted. However, a strict separation between R&D and trade innovations will be difficult to make, because R&D do partially measure innovations lowering transaction costs. It may be useful to make a further breakdown into various types of investments which enhance the division of labour and productivity. As yet spillovers between these different types of knowledge investments will complicate the analysis but can also give an indication for the need of government intervention in case of externalities.

Second, the existence of reverse causality between TFP and trade innovations can influence the results. This reverse causality, or more precisely the proposition that the causality runs from productivity to trade, is a much discussed issue in the literature. It is, in fact, part of a more general discussion on the determinants of the "make or buy" decision, where transaction costs and R&D spillovers play an important role (see Gattai, 2005 and Lumanega –Neso, Ollarreaga and Schiff, 2005). In our view there is, from the transaction costs perspective, reason to assume that causality runs (also) from the innovative skills to reduce transaction costs to productivity. In our empirical analysis we tried to avoid the problem of reversed causality by specifying the explanatory variables with lags. A related question for further research regards the impact of these trade innovations on employment, at home and abroad. Up to now the focus is on employment changes and labour market dynamics because of an international rearrangement of jobs in the production sector, including "production" of services (see the survey by Hoekman and Winters, 2005). No much attention is paid to the transition of workers from the production to the transaction sectors and to the worldwide division of labour in this respect. Future research may deal with these problems and provide more empirical evidence on the contribution of trade innovations to productivity growth.

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Appendix: Data Sources

Total Factor Productivity
Data on TFP for the six countries (France, Germany, Italy, Netherlands, United Kingdom and the United States) during the 1981-2001 period have been taken from the Total Economy Growth Accounting Database of Groningen Growth & Development Centre (GDDC). This data is taken from Timmer et al. (2003) and is an extension of previous work by Van Ark et

al. (2002). Here, data on TFP has been derived using the growth accounting approach. It should be noticed that growth in capital input is measured by capital service flows.

For the 1951-1992 period data on TFP in the Netherlands is taken form Van Ark and De Jong (1996). They derive TFP in two different manners. The first method is based on a traditional 'Solow' model, which assumes constant returns to scale. The second method relaxes the assumption of constant returns to scale. Here, investment in R&D is incorporated with the assumption that technical change creates significant spillover effects. This paper uses data on TFP derived using the first method.

Research and Development
R&D data for the six countries for the 1981-2001 period have been obtained from the OECD Main Science and Technology Indicators Database. The standard expenditure measure is the Gross Domestic Expenditure on Research and Experimental Development (GERD), which covers all R&D carried out on national territory in the year concerned (OECD 2004). This is essentially based on retrospective surveys of the units carrying out the R&D though national forecasts have been included when available. The indicators are based on the sum of performers' reports of their R&D expenditure and personnel on national territory (i.e. excluding payments to international organizations and other performers abroad). In this database GERD is presented in millions $ in constant 2000 prices and Purchasing Power Parities. Data for the United Kingdom for the years 1982 and 1984. The figures for these years are obtained by linear interpolation. Growth rates of R&D expenditure are derived as the first logarithmic difference (Δ ln).

Data on R&D for the Netherlands during the 1951-1992 period is given in Van Ark and De Jong (1996). They use data on investment in research and development provided by a study of the Dutch Central Planning Bureau (Minne, 1995). This data is converted into 1990 guilders and cumulated assuming a service life of 15 years for each investment in R&D to obtain the stock of research and development.

Trade Innovations
As mentioned in this paper, trade innovations are measured by the difference between the growth of trade and the growth of production. Trade growth is measured as the average growth of import and export. To derive trade innovations data is thus needed on GDP, import and export.

Production, import and export data for the 1981-2001 period for France, Germany, Italy, the Netherlands, the United Kingdom and the United States have been taken from OECD Economic Outlook No. 76. For the Netherlands data on production, import and export till 1960 are also available in the OECD Economic Outlook No. 76. For the 1951-1960 period, data on import and export can be found in the United Nations 'Handbook of international trade and development statistics'. Data on GDP for this period can be found in CBS (Dutch Central Bureau for Statistics) STATLINE. Growth rates of production, export and import are derived as the annual percentage change. The data has already been corrected for inflation.