Vrije Universiteit Brussel

VRIJE
UNIVERSITEIT
BRUSSEL

The Economic Impact of Standards in Belgium
Buts, Caroline; Van Droogenbroeck, Ellen; Dooms, Michael; Willems, Kim

The Economic Impact of Standards in Belgium

Caroline Buts, Vrije Universiteit Brussel, Belgium

Ellen Van Droogenbroeck, Vrije Universiteit Brussel, Belgium

Michaël R. J. Dooms, Vrije Universiteit Brussel, Belgium

Kim Willems, Vrije Universiteit Brussel, Belgium

ABSTRACT

While several past studies have measured the impact of standards on indicators such as output and productivity for a variety of countries, a quantitative analysis that focuses on Belgium has not been performed yet. Based on a dataset containing sector level data spanning 25 years (1994-2018), the authors find that, next to capital investment and the number of patents, standards make a statistically significant, positive and substantial contribution to Belgian GDP as well as to labor productivity. More specifically, one additional standard will on average increase GDP by €2.04 million per year and will increase labor productivity per person employed by €11.5. In addition, standards contribute to about 0.2% of GDP, 19% of GDP growth, and 19% of labor productivity growth.

KEYWORDS

Economic Impact, GDP, Knowledge Dissemination, Labor Productivity, NBN, Panel Data, Regression Analysis, Sector, Standards

1. INTRODUCTION

For many companies and the economy to benefit most from innovation, new knowledge needs to be broadly disseminated. Standards facilitate this dissemination process and constitute a *"formula that describes the best way of doing something, … standards are the distilled wisdom of people with expertise"* (ISO, 2020). Standards, that are by nature developed through cooperation and consensus of large companies, SMEs, public institutions, federations, societal stakeholders and industry experts, clearly facilitate the dissemination of knowledge as they are available to all.

Intuition as well as scientific literature indeed confirm the social and economic benefits of standardization. Ramdani et al. (2019) explain that reference standards directly impact overall efficiency, minimal admissibility standards mainly protect the consumer, whereas product compatibility standards benefit the consumer as well as the firm (although the impact can differ across firms). Regarding the macro-economic level, we also learn about the positive impact of standardization as *"codified technological know-how contributes to economic growth"* (Blind & Jungmittag, 2008, p. 51). As such, standards contribute to productivity and growth by improving efficiency and interoperability, facilitating innovation and increasing trade as documented by for example Hogan et al. (2015).

In general, the theoretical and empirical examination of the role of standards is a relatively recent phenomenon in the economic literature (de Vries et al., 2018; Haimowitz & Warren, 2007). Especially empirical evidence on the macroeconomic impact of standards is scant. While several studies measure the impact of standards on indicators such as output and productivity, the link between standardization and economic growth has not yet been analyzed in depth and has not taken all country differences into account (Blind & Jungmittag, 2008; de Vries et al., 2018; Heikkilä et al., 2020). This article aims to shed more light on this research gap and contributes to the literature in three ways. *First*, our study focuses on Belgium, a country for which – to the best of our knowledge – a quantitative analysis is not yet available. The Belgian case is interesting, given its distinct characteristics, as a small, very open economy ranking 3rd on the KOF Globalization Index (Gygli et al., 2019), with inward FDI exceeding outward FDI, which is considered atypical for a developed economy with a savings surplus (Duprez & Van Nieuwenhuyze, 2016). Furthermore, its economy is characterized by very high labor productivity (4th in the 2019 OECD ranking), coupled to high real wage levels and low productivity growth, which has pushed companies located in Belgium to increasingly substitute labor by capital (OECD, 2019; Schwellnus et al., 2018). In such a context of high labor productivity with limited growth potential, and high ongoing substitution of labor by capital, and with country competitiveness under pressure at a global level, it is worthwhile to isolate the impact of standards on GDP and labor productivity growth. This allows to determine whether results of previous studies on the impact of standards on economic growth, hold in this particular context. *Second*, whereas the majority of existing publications take into account only one indicator of economic growth, we econometrically study the

impact of standards on both output and labor productivity. *Third*, our study responds to the call for quantitative studies based on 'real data' from standard bodies, statistical offices, and trade organizations (de Vries et al., 2018). In particular, the current study relies on a collaboration with the Belgian Bureau for Standardization (NBN). NBN develops, publishes and disseminates standards; together with its sectoral operators, NBN serves as the Belgian knowledge hub of standardization.

The purpose of this article is to econometrically estimate the impact of standards on GDP and labor productivity in Belgium. To that end, we build on the methodologies developed in the literature and compose a Cobb-Douglas model of production, comprising capital, labor, and total factor productivity. The latter includes standards, patents, and recession. By means of a panel regression, for twelve Belgian sectors covering 25 years from 1994 until 2018, we find that, next to capital investment and the number of patents, standards make a statistically significant, positive and substantial contribution to output as well as to labor productivity. Across industries, the development and publication of one additional standard will on average increase GDP by €2.04 million per year and will increase labor productivity per person employed by €11.5. In addition, standards contribute to about 0.2% of GDP, 19% of GDP growth and 19% of labor productivity growth.

The remainder of this article is structured as follows: Section 2 describes the literature and the relevant econometric models as well as their results. Subsequently, Section 3 presents the research question, methodology and data for Belgium. Next, Section 4 presents the analysis and discusses the main results. The final section concludes.

2. LITERATURE

Research on standardization is growing and covers diverse topics such as management of standardization, conformity assessment, IP rights and the impact of standards (de Vries et al., 2018). While these lines of literature are quite diverse, they largely agree on the positive impact of standards. The importance of standards is indeed widely documented for diverse sectors such as manufacturing (Martin & Bell, 2016), healthcare (De Regge et al. 2019), and ICT (Baron et al., 2019). In addition, we learn about the added value of standards across industries covering specific topics as innovation (Hawkins et al. 2017) and quality control (Burda, 2017). For more extensive reviews of the impacts of standards we refer to the work of Swann (2000; 2010) who identified eight purposes of standards 1) variety reduction, 2) quality & performance, 3) measurement, 4) codified knowledge, 5) compatibility, 6) vision, 7) health & safety, and 8) environment. This list clearly shows that our understanding on the impact of standards has extended over time as early research by David (1987 as cited by Heikkilä, 2020) distinguished only three aims of standards: 1) compatibility or interoperability, 2) minimum quality or safety and 3) variety reduction. Considering the focus of our analysis, we now proceed with literature on the macroeconomic impact of standards. Overall, it is broadly acknowledged that technological know-how contributes to

economic performance. However, earlier literature on technology and economic growth rather focuses on R&D expenditures and patents than on standards. While several studies show that societies underinvest in R&D (Jones & Williams, 2000; Lucking et al., 2018), much less empirical evidence exists whether societies under- or overinvest in standardization. Actually, economic growth theory is almost silent about the macroeconomic impacts of standards (Baron & Schmidt, 2014; Blind & Jungmittag, 2008; Swann, 2010). Indeed, a recent bibliometric analysis by Heikkilä et al. (2020) shows that the top 5 economics journals have published no articles related to the link between standardization and economic growth in the period 1996-2018. In addition, a representative sample of leading researchers of economic growth seems to have allocated little attention to the topic. Still, there is no doubt that standards are very important for the fast and efficient diffusion of new technologies (Blind & Jungmittag, 2008; Swann 2000). In this respect, Blind & Jungmittag (2008, p. 51) state that *"standards can also be interpreted as institutions"*, an economic concept that is defined by North (1991, p. 97) as *"the humanly devised constraints that structure political, economic, and social interaction"*. In the recent economic literature, several authors have extensively discussed the role of institutions as determinants of economic growth (e.g. Acemoglu & Robinson, 2012; 2019; Maze, 2017; North, 1991). As standards promote the diffusion of technologies, interoperability and network effects, foster competition, and reduce transaction and measurement costs, they can be acknowledged as important institutions that matter for technological progress and, therefore, for economic growth and development (Barzel, 2007; Blind & Jungmittag, 2008; Heikkilä, 2020; Maze, 2017; Swann, 2000). This view goes against the conventional idea that standards may act as barriers to innovation (see for example Maxwell, 1998). However, the interplay between standardization and innovation – and the accompanied engine for economic growth – has received increasingly attention (Acemoglu et al., 2012; Zoo et al., 2017). In the remainder of this section, we focus on recent studies that empirically discuss the role of standards from a macroeconomic perspective We document a consensus regarding the importance of standards for the efficient dissemination of knowledge as well as for macroeconomic performance. For example, Padilla et al. (2017) document that 20% to 30% of GDP growth is typically attributed to standards. In what follows, we briefly discuss the main econometric findings of macroeconomic studies focusing on the impact of standards on labor productivity and output, starting with the seminal work of Blind & Jungmittag (2008).[2] An overview of these impact studies is provided in Table 1. Blind & Jungmittag (2008) study the effect of standards on economic growth for twelve sectors in four European countries from 1990 until 2001.[3] They find a significant impact of standards on economic growth for the overall model including four countries as well as for single country models. The effect is especially visible in sectors that have reached the maturity phase as well as those with a lower R&D intensity. Patents however seem to be more important in R&D intense industries. Building on Blind & Jungmittag (2008), we also find six single country studies performing an econometric analysis on the macroeconomic impact of standards. First, a substantial positive impact of

standardization has been documented for France (Miotti, 2009). From 1950 until 2007, standards have contributed to about 25% of GDP growth. Second, Stokes et al. (2011) study the effect of standards in New Zealand between 1978 and 2009. The documented positive effect of standards on total factor productivity takes on similar proportions as in France (Miotti, 2009). The positive impact of standardization on labor productivity is comparable to older results regarding the UK (Temple et al., 2004). Third, Blind et al. (2011) document a positive effect of standards on growth in Germany covering the period from 1960 until 2006. They relate the stock of standards to the diffusion of technological knowledge and a subsequent effect on economic growth: i.e. the higher the stock of standards, the more knowledge dissemination and the higher German economic growth. Fourth, a similar positive impact of standards has been found for Australia by Standards Australia (2012). Whereas a previous study documented the impact of standards on total factor productivity in Australia (CIE, 2006), the more recent version focuses on GDP and extends the scope to cover 28 years from 1982-2010. A fifth single country focus on the UK can be found in Hogan et al. (2015). From 1921 until 2013, standards contribute to the growth of annual labor productivity as well as of GDP by 37.4% and 28.4% respectively. Standards also boost international trade in the UK. Depending on the industry, the effect of standards on exports ranges from 0.3% to 9.9%. Sixth, regarding Canada and the timeframe from 1981 until 2014, CBoC (2015) finds that standardization contributes to 16% of labor productivity growth and to about 8% of GDP growth. Interestingly, Blind (2015) adds that the macroeconomic impact of standards is lower in countries with less standardization such as China. More recently, Menon (2018) takes again a broader perspective and studies the impact of standards in the Nordic economies involving five countries in the analysis.[4] They argue that standards affect productivity via better interoperability, less variety of intermediate goods, higher quality and dissemination of technical information. They model that labor productivity is a function of capital intensity and total factor productivity. The latter entails factors such as standards, patents, regulation and recession. Menon (2018) finds that standards increase labor productivity for the entire Nordic region, as well as for each individual country. More specifically the study finds that a doubling of the stock of standards boosts labor productivity by 10.5%. Also, the number of patents plays an important role for labor productivity in the entire Nordic region. However, the country focus documents that patents affect productivity in Denmark and Iceland, but do not have a statistically significant impact on productivity in Finland, Norway and Sweden. The extant macroeconomic impact studies on standards cover diverse countries and timeframes. In addition, they employ a rather straightforward methodology on a very complex dynamic. While they uncover effects of diverse magnitudes, the results clearly indicate a consensus regarding the positive macroeconomic effects of standardization on labor productivity as well as on economic growth.

Table 1. Overview of the macroeconomic (econometric) impact studies

Country	Organization/Authors	Year	Timeframe	Main Dependent Variable(s)
France, Germany, Italy, UK	Blind & Jungmitttag	2008	1990-2001	Added value
France	AFNOR	2009	1950-2007	Output
Germany	DIN	2011	2002-2006	Output
New Zealand	BERL	2011	1978-2009	Productivity
Australia	Standards Australia	2012	1982-2010	Output
Canada	CBoC	2015	1981-2014	Output and Productivity
UK	Cebr	2015	1921-2013	Productivity
Nordic	Menon	2018	1976-2016	Productivity

Source: Own compilation based on literature review

3. RESEARCH QUESTIONS, METHODOLOGY AND DESCRIPTIVE STATISTICS

From the literature review we learn that standards have a positive impact on economic performance, measured as output and labor productivity. However, empirical economics of standards is only in its infancy and the relationship between standards and economic growth has not yet been documented for Belgium specifically. In addition, the majority of the existing studies focusses on only one indicator of economic performance (see Table 1). Our research questions hence read as follows:

RQ$_1$: Do standards affect total output?
RQ$_2$: Do standards affect labor productivity?

Following the literature we assume a positive impact of standards on output and productivity and thus formulate the following hypotheses:

H$_1$: Standards have a positive impact on output.
H$_2$: Standards have a positive impact on labor productivity.

To answer the research questions, we build on the methodologies developed in the literature for the composition of the econometric models (e.g. Blind & Jungmittag, 2008; Hogan et al., 2015 and Menon, 2018). We use a Cobb-Douglas production function to describe how output (expressed as GDP) is a non-linear function of labor force (L), the capital stock (K), and Total Factor Productivity (TFP). The latter measures the efficiency with which the input factors K and L are combined to produce output and entails factors such as standards, patents, and recession:

$$Y_t = A_t L_t^\alpha K_t^{1-\alpha}$$

By taking the natural log of both sides of this equation the Cobb-Douglas production function can be transformed into a per-worker production function in which output per worker (labor productivity) is a linear function of capital per worker (capital-employment ratio) and TFP.

For the purpose of our study, we build two models where output (GDP) and labor productivity constitute the respective *dependent variables* as depicted in a simplified version in Figure 1, where TFP entails the usual factors such as standards, patents and recession.

Figure 1. Conceptual model
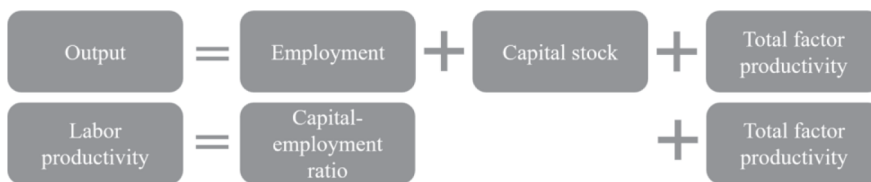
Source: Own elaboration, inspired by Blind & Jungmittag, 2008; Hogan et al., 2015; and Menon, 2018.

Based on data availability, we cover the period from 1994 until 2018. This means that the number of observations is limited. In addition, we find serious multicollinearity issues when estimating at the country level. To overcome these difficulties, we move to the sector level and include for each year 12 sectors.[5]

This approach substantially increases the number of observations as well as the validity of the model. Whereas either output or labor productivity per sector per year is the dependent variable, standards constitute our main *independent variable* of interest. While several options are available, we opt for the net stock of standards per sector per year. The net stock of standards comprises all published and active standards within a year (hence taking out the standards that have been withdrawn). Note that the aim of this study is to measure the impact of *standards* and not the impact of *standardization* – i.e. *"the process of development and application of standards"* (ISO/IEC, 2004).

Next to standards, the model is completed with the usual *control variables*, i.e. either net capital stock or the capital employment ratio expressing the capital intensity of a sector in a year, patents measuring innovative performance, and recession (e.g. Blind & Jungmittag, 2008; Hogan et al., 2015 and Menon, 2018). For the model estimating output, we also include employment.

The regression equations examining the impact of the net stock of standards on output and labor productivity thus read as follows, with *i* indicating the sector and *t* the year:

$$Output_{it} = \alpha + \beta_1 Employment_{it} + \beta_2 Net\ capital\ stock_{it}$$
$$+\beta_3 Net\ stock\ of\ standards_{it} + \beta_4 Patents_{it} + \beta_5 Recession_{it} + \varepsilon_{it} \tag{1}$$

$$Labor\ productivity_{it} = \alpha + \beta_1 Capital\ employment\ ratio_{it}$$
$$+\beta_2 Net\ stock\ of\ standards_{it} + \beta_3 Patents_{it} + \beta_4 Recession_{it} + \varepsilon_{it} \tag{2}$$

Our panel dataset consists of 12 sectors covering a period from 1994 until 2018, leading to 300 observations. Table 2 provides a full overview of the descriptive statistics, including two versions of labor productivity and of the capital employment ratio, expressed per person employed (ppe) as well as per hour worked (phw).

The dependent variable to test the first research question, GDP, is retrieved from OECD (2019b) and presents the output per sector per year and is expressed in € millions. Total output per sector per year is lowest for electrotechnology and highest for services. The evolution of total output per sector is presented in Figure 2.

To test our second research question, we run two estimations, explaining labor productivity per person employed and per hour worked respectively. Labor productivity is lowest in healthcare, health and safety and highest in energy and utilities. An overview of the evolution of labor productivity per person employed is presented for each sector in Figure 3.

As for the independent variables, employment represents total employment per sector per year and is expressed in thousands. The lowest value, 14.200, is measured for electrotechnology in 2018. Maximum employment in the dataset is over 2 million in services in 2018. The net capital stock measures the capital intensity of a sector per year and is defined as the sum of the written-down values of all fixed assets that are in use. Also this data stems from OECD (2019e) and is expressed in € million. It

Table 2. Descriptive statistics for Belgium – Dataset sector based

Variable Name	Mean	Std Dev	Min	Max	Source[6]
GDP	63066.7	70420.5	3079.90	322234	OECD
Labor productivity (ppe)	283624	223850	87608.3	1203327	OECD
Labor productivity (phw)	174.966	137.196	60.8000	738.400	OECD
Employment	361.228	522.536	14.2000	2262.60	OECD
Net capital stock	83816.5	171614	2136.20	751388	OECD
Capital employment ratio (ppe)	214191	198430	60436.9	898609	OECD[7]
Capital employment ratio (phw)	132.977	122.357	37.9000	551.900	OECD[8]
Net stock of standards	1579.50	1514.12	57	7352	NBN CENELEC[9]
Patents	50.3600	51.1296	0	264	OECD
Recession	0.19293	0.39523	0	1	OECD[10]

Source: Own compilation based on the new dataset

Figure 2. Evolution of total output per sector (in € millions)
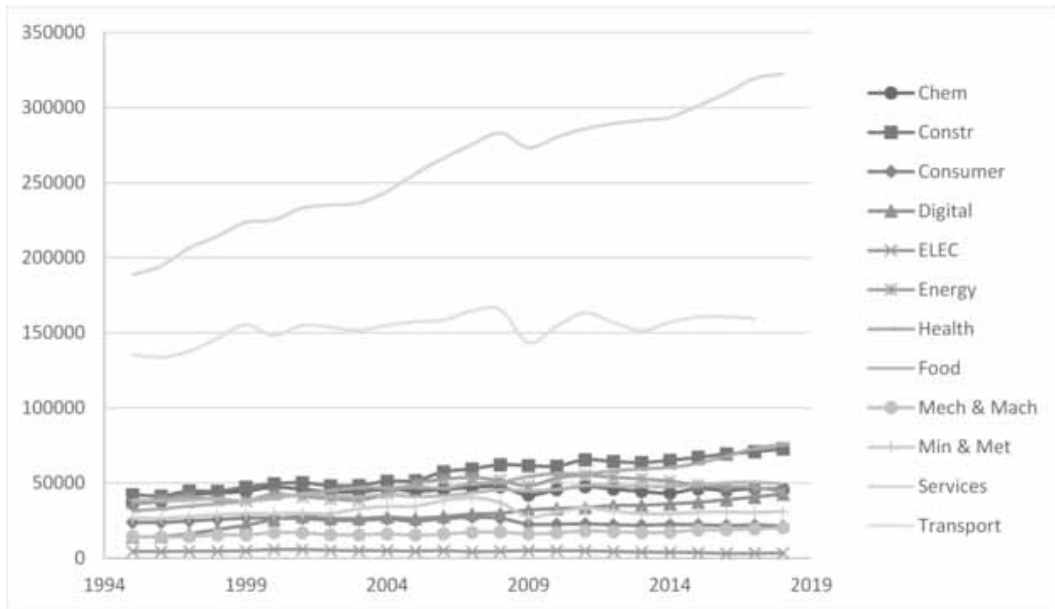
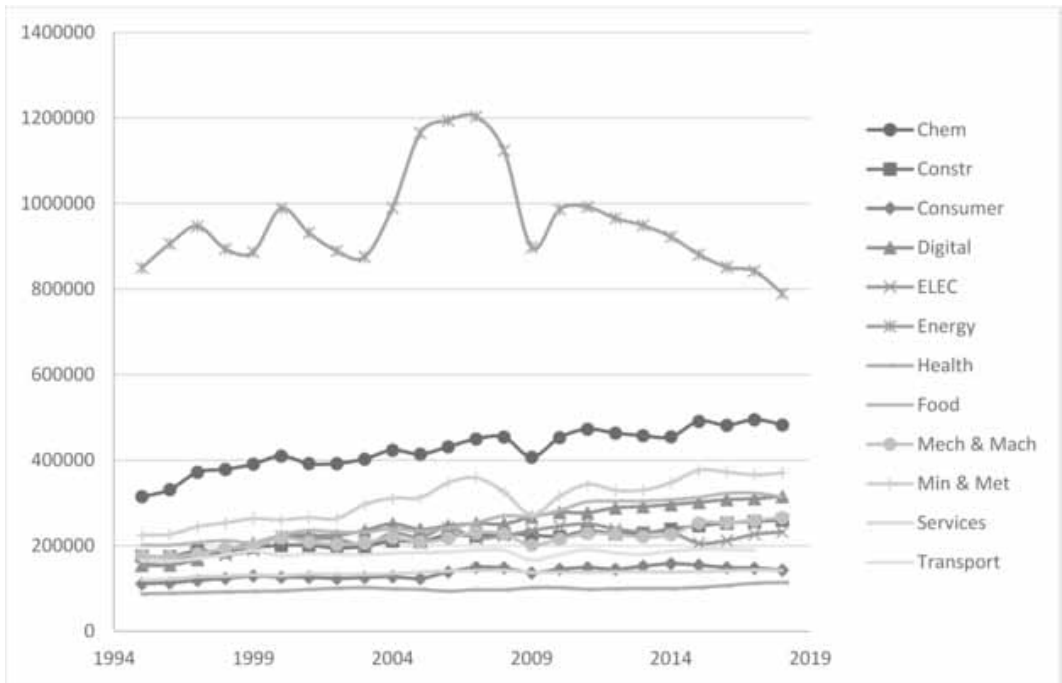Source: Own compilation based on OECD data

ranges from €2.136 million in electrotechnology to €751.388 million in services. The variable capital employment ratio measures the capital intensity of each sector per year either per person employed or per hour worked. Construction in 1995 seems to be the least capital intense sector whereas energy and utilities is the most capital intensive. The net stock of standards constitutes our variable of interest and is provided by NBN (2019) and by CENELEC (2019) for the sector 'electrotechnical'. It ranges from 57 for food and agriculture in 1994 to 7.352 for electrotechnology in 2018. Measuring the use of standards could constitute an alternative for the net stock of standards. Individual sales data are then the best option. Sales of individual standards has however evolved to a right to access a platform with a collection of standards. Therefore, a potential variable 'sales' becomes less accurate. An overview of the evolution of the net stock of standards per sector can be found in Figure 4.[11]

The variable patents, measuring innovative performance, is retrieved from OECD (2019d) and ranges from 0 to 264 with 0 patents in services in 1995 and the maximum value 264 for mechanical and machinery in 2018[12]. The variable recession is a dummy which takes on the value of 1 in times of recession, defined as at least two subsequent quarters of economic slowdown.

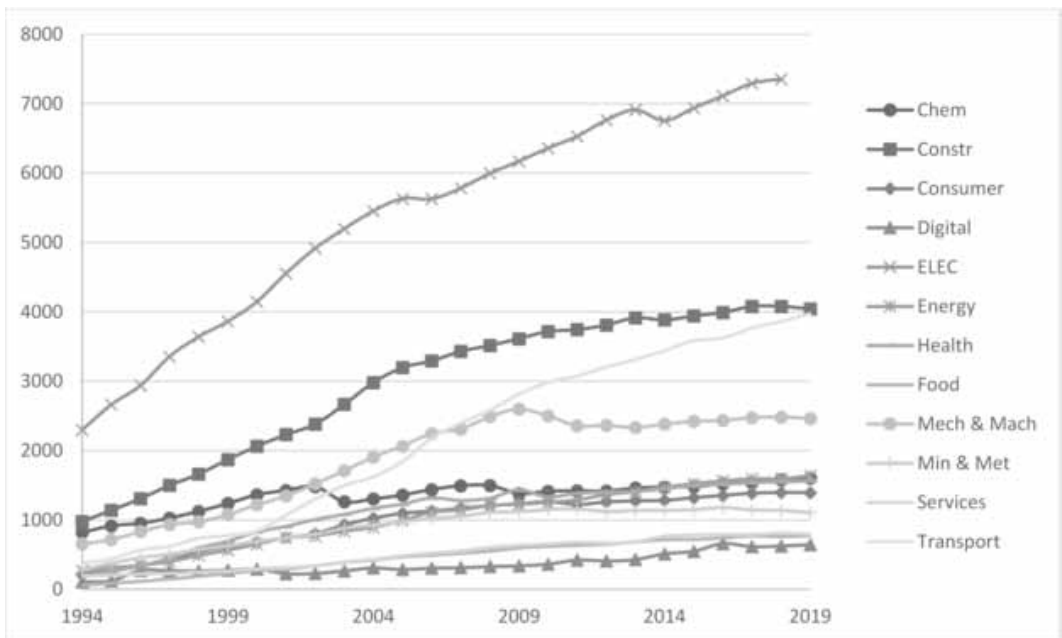## 4. ANALYSIS AND RESULTS

This section investigates the impact of standards on output and labor productivity and answers the two research questions. The analysis hence takes a rather macro-

Figure 3. Evolution of labor productivity

Source: Own compilation based on OECD data

Figure 4. Evolution of the net stock of standards

Source: Own compilation based on data provided by NBN and CENELEC

economic perspective. It is however important to note that also the standardization process itself constitutes a platform for knowledge exchange. It generates incremental and directly useful technological know-how. The present analysis looks at the net stock of standards which constitutes a rough but reliable measure for the impact of standards. Nevertheless, the current methodology will likely lead to an underestimation of the total impact as broader knowledge dissemination benefits from, for example the standardization process itself, are not taken into account.[13]

To study the first research question regarding the impact of standards on total output, we run a panel regression including all twelve sectors, covering 25 years from 1994 until 2018. The test thus entails twelve groups and, as a result of a few missing datapoints, 264 observations. Table 3 provides an overview of the results.

When interpreting Table 3, we first focus on the variable of interest, i.e. the net stock of standards. Our panel regression reveals a strongly significant and positive effect of standards on output. Across industries, the development and publication of one additional standard will on average increase GDP by €2.04 million per year.

Considering GDP growth as well as the average amount of standards and the average level of GDP per sector per year, standards contribute on average about 19% to GDP growth and 0.2% to yearly GDP. This impact is clearly substantial. The results thus confirm our first research hypothesis that standards have a positive impact on output. The results for the control variables largely confirm the findings in the literature. Employment, capital as well as patents positively contribute to a sector's GDP. We do not find a significant result for recession impacting the output at sector level.

The second research question studies the impact of standards on labor productivity. The panel regression again covers the twelve sectors over 25 years, from 1994 until

Table 3. Explaining output, 1994-2018

Variable Name	Impact on GDP
Employment	75.491*** (11.273)
Net capital stock	0.2739*** (0.0330)
Net stock of standards	2.0415*** (0.4494)
Patents	47.457*** (12.949)
Recession	694.26 (594.22)
Observations	264
Groups	12
R^2	0.9280
Wald chi2	2207.5***

Coefficients reported; ***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level; standard errors in parentheses
Source: Own compilation based on quantitative analysis

2018. Table 4 presents the results of the panel regression explaining labor productivity expressed per person employed as well as per hour worked.

Table 4. Explaining labor productivity, 1994-2018

Variable Name	Labor Productivity (ppe)	Labor Productivity (phw)
Capital employment ratio (ppe)	0.5011*** (0.1046)	/
Capital employment ratio (phw)	/	0.4010*** (0.1073)
Net stock of standards	11.546** (4.4678)	0.0087*** (0.0027)
Patents	413.52*** (130.37)	0.2303*** (0.0784)
Recession	6090.4 (6123.2)	4.3602 (3.6859)
Observations	264	264
Groups	12	12
R^2	0.8349	0.8104
Wald chi2	66.260***	64.050***

Coefficients reported; ***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level; standard errors in parentheses
Source: Own compilation based on quantitative analysis

Again, directly focusing on the variable of interest, we report a positive and statistically significant impact of standards on labor productivity. This means that an increase in the net stock of standards increases labor productivity in Belgium. This holds for both tests, i.e. studying labor productivity per person employed as well as per hour worked. We note that an increase in the net stock of standards by one unit increases productivity per person employed by €11.5. Considering the level of standards and labor productivity growth, we find that standards contribute about 19% to labor productivity growth. Similar results are obtained when studying labor productivity per hour worked. Logically, the reported coefficient is smaller. These results thus convincingly confirm the second hypothesis that standards positively contribute to labor productivity. Regarding the control variables we find a very positive and substantial impact of the capital employment ratio. This result follows intuition as well as the literature as higher capital investment in a sector results in higher labor productivity. Also patents positively and significantly contribute to productivity. Recession, however, does not significantly affect productivity.

Table 5 compares the results for Belgium to the extant literature. We note that for the contribution of standards to GDP growth, Belgium lies in the middle range, i.e. substantially higher than Canada but lower than France, the Nordic countries and the UK. As for contribution of standards to GDP, Belgium is rather in the lower range, together with Canada and the UK. We also point to the contribution of standards to

labor productivity which varies between countries. Standards have a higher contribution to labor productivity growth in Belgium than in Canada, but lower than in France, the Nordic countries and the UK. The Belgian position is potentially related to the shorter period for Belgian observations (only starting in 1994, as opposed to other countries starting at least from the early 1980s, or earlier). It can be expected that the larger productivity gains have been obtained pre-1994, and that marginal increases of labor productivity have been lower given the high position of Belgium in OECD productivity rankings. Indeed, Belgium ranks fourth in the 2019 OECD labor productivity ranking. In addition, comparing the productivity gain of Belgium pre-1994 to the period of the sample clearly indicates a lower productivity growth in recent years, i.e. 24.5% (1994-2019) versus 69.4% (1970-1993).

Table 5. Comparison of the results for Belgium with other countries

	Belgium	Australia	Canada	Fr/De/It/UK	France	Germany	New Zealand	Nordic	UK
Organization	VUB	Standards Australia	CBoC	Blind & Jungmittag	AFNOR	DIN	BERL	Menon	Cebr
Year	2020	2012	2015	2008	2009	2011	2011	2018	2015
Timeframe	1994-2018	1982-2010	1981-2014	1990-2001	1950-2007	2002-2006	1978-2009	1976-2016	1921-2013
Main dependent variable(s)	Output and Productivity	Output	Output and Productivity	Added value	Output	Output	Productivity	Productivity	Productivity
Variable of interest: standards									
Standards	+	+	+	+	+	+	+	+	+
Contribution to Δ output	19%	/	8%	/	25%	/	/	28%	28%
Contribution to output	0.2%	0.8%	0.2%	/	0.8%	0.7-0.8%	0.8-1%	/	0.3%
Contribution to Δ productivity	19%	/	16%	/	27%	/	/	39%	37%
Control variables									
Capital	+	+	+	+	+	+	+	+	+
Patents	+	+	NI	+	+	+	NS	+	NI
Recession	NS	NI	NI	-	-	-	NI	NS	-

NS: not statistically significant; NI: not included
Source: Own compilation based on literature review and comparison of results

5. CONCLUSION

The literature review documents a clear positive relationship between the amount of standards and economic performance. Indeed, standards contribute to growth and productivity by disseminating knowledge, enhancing efficiency and boosting international trade. The aim of this article is to econometrically estimate the impact of standards on GDP and labor productivity in Belgium. Thereto, we build a dataset at sector level for all twelve Belgian sectors covering 25 years from 1994 until 2018.

By means of a panel regression, we document a positive effect of standards on GDP as well as on labor productivity which is in line with the extant literature (e.g. Blind & Jungmittag, 2008; CBoC, 2015; and Menon, 2018). The results show that the positive relationship between the amount of standards and economic performance holds for a small, very globalized economy, at a very high level of labor productivity and with increasing substitution of labor by capital. As always, this study is not without limitations. First, we note that these results likely constitute an underestimation of the effect of standards as, for example, also the standardization process itself already contributes to knowledge dissemination. Such elements are not captured by the variable net stock of standards. Second, while issues resulting from a low number of observations and multicollinearity are solved by focusing on the sector level, we emphasize that the results hold for the typical average sector and that coefficients should be cautiously interpreted.

We can summarize that across industries, the development and publication of one additional standard will on average increase GDP by €2.04 million per year and will increase labor productivity per person employed by €11.5. Considering the average number of active standards, this is a substantial impact, thereby confirming our research hypotheses. It seems that standards contribute to about 0.2% of GDP, 19% of GDP growth and 19% of labor productivity growth. Comparing Belgium to other country studies, we find that the size of the effect can be situated more or less in the middle range. Future research will hopefully be able to reveal whether this always holds or rather depends on the timeframes studied, as well as the specific macro-economic context of the countries. As literature documents differences between countries, additional research on the interaction of standards with other context variables such as openness, level of productivity and industry structure could certainly add value.

REFERENCES

Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail*. Crown.

Acemoglu, D., & Robinson, J. A. (2019). Rents and economic development: The perspective of Why Nations Fail. *Public Choice*, *181*(1-2), 13–28. doi:10.1007/s11127-019-00645-z

Acemoglu, D., Gancia, G., & Zilibotti, F. (2012). Competing Engines of Growth: Innovation and Standardization. *Journal of Economic Theory*, *147*(2), 570–601. doi:10.1016/j.jet.2010.09.001

BaronJ.SchmidtJ. (2014). *Technological Standardization, Endogenous Productivity and Transitory Dynamics*. Banque de France Working Paper No. 503. Available at https://ssrn.com/abstract=247870710.2139/ssrn.2478707

Baron, J., Contreras, J. L,.Husovec, M., Larouche, P., & Thumm, N. (2019). *Making the Rules: The Governance of Standard Development Organizations and their Policies on Intellectual Property Rights*. JRC Science for Policy Report, EUR 29655 EN.

Barzel, Y. (2007). Standards and the Form of Agreement 2002 Presidential Address Western Economic Association. *Economic Inquiry*, *42*(1), 1–13. doi:10.1093/ei/cbh040

Blind, K., & Jungmittag, A. (2008). The impact of patents and standards on macroeconomic growth: A panel approach covering four countries and 12 sectors. *Journal of Productivity Analysis*, *29*(1), 51–60. doi:10.1007/s11123-007-0060-8

Blind, K., Jungmittag, A., & Magelsdorf, A. (2011). *The Economic Benefits of Standardization – An update of the study carried out by DIN in 2000*. DIN German Institute for Standardization.

Blind, K. (2015). *The Influence of Standardization on Innovation and Economic Growth: State-of-the-art for Research and Policy*. Presented at the *ICES Conference*, Korean Standards Association.

Burda, A. (2017). The Social and Economic Importance of Standardization Ensuring Auditing and Certifying the Quality of Goods. *Knowledge Horizons – Economics, 9*(4), 62-64.

CBoC. (2015). *Getting Aligned. How Adopting Standards Affects Canada's Productivity and Growth*. Report by the Conference Board of Canada to the Standards Council of Canada.

CENELEC. (2019). *Net Stock of Standards.* Author.

CIE (Centre for International Economics). (2006). *Standards and the Economy*. Standards Australia.

David, P. (1987). Some new standards for the economics of standardization in the information age. In P. Dasgupta & P. Stoneman (Eds.), *Economic Policy and Technology Performance*. Cambridge University Press. doi:10.1017/CBO9780511559938.010

De Regge, M., Gemmel, P., & Meijboom, B. (2019). How Operations Matter in Healthcare Standardization. *International Journal of Operations & Production Management*, *39*(9/10), 1144–1165. doi:10.1108/IJOPM-03-2019-0227

de Vries, H., Jakobs, K., Egyedi, T. M., Eto, M., Fertig, S., Kanevskaia, O., Klintner, L., Koch, C., Mijatovic, I., Mirtsch, M., Morone, P., Orviska, M., Riillo, C., & Scaramuzzino, G. (2018). Standardization: Towards an agenda for Research. *International Journal of Standardization Research*, *16*(1), 52–59. doi:10.4018/IJSR.2018010104

Duprez, C., & Van Nieuwenhuyze, C. (2016). Belgium's inward and outward foreign direct investment. *Economic Review - National Bank of Belgium, 2*, 45-62.

Gygli, S., Haelg, F., Potrafke, N., & Sturm, J.-E. (2019). The KOF Globalisation Index – Revisited. *The Review of International Organizations*, *14*(3), 543–574. doi:10.1007/s11558-019-09344-2

Haimowitz, J., & Warren, J. (2007). *Economic Value of Standardization*. The Conference Board of Canada.

Hawkins, R., Blind, K., & Page, R. (Eds.). (2017). *Handbook of Innovation and Standards*. ElgarOnline. doi:10.4337/9781783470082

HeikkiläJ.Ali-VehmasT.RissanenJ. (2020). Connecting the Dots: A Bibliometric Analysis of the Link Between Standardization and Economic Growth. https://ssrn.com/abstract=359065710.2139/ssrn.3590657

Hogan, O., Sheehy, C. & Jayasuriya, R. (2015). *The Economic Contribution of Standards to the UK Economy*. Cebr Report.

ISO. (2020). *Standards*. Retrieved from https://www.iso.org/standards.html

ISO/IEC. (2004). Standardization and Related Activities — General vocabulary (8th ed.). Author.

Jones, C., & Williams, J. (2000). Too Much of a Good Thing? The Economics of Investment in R&D. *Journal of Economic Growth*, *5*(1), 65–85. doi:10.1023/A:1009826304308

Jungmittag, A., Blind, K., & Grupp, H. (1999). Innovation, standardisation and the long-term production function. A cointegration analysis for Germany 1960-96. *Zeitschrift für Wirtschafts- und Sozialwissenschaften*, *119*, 205–222.

Lucking, B., Bloom, N., & Van Reenen, J. (2018). *Have R&D Spillovers Changed?* NBER Working Paper No. 24622. Retrieved from https://www.nber.org/papers/w24622

Martin, T. D., & Bell, J. T. (2016). *New Horizons in Standardization Work: Techniques for manufacturing and Business Process Improvement*. CRC Press.

Maxwell, J. W. (1998). Minimum Quality Standards as a Barrier to Innovation. *Economics Letters*, *58*(3), 355–360. doi:10.1016/S0165-1765(97)00293-0

Maze, A. (2017). Standard-setting Activities and New Institutional Economics. *Journal of Institutional Economics*, *13*(3), 599–621. doi:10.1017/S174413741600045X

Menon. (2018). *The Influence of Standards on the Nordic Economies*. Menon Publication No 31/2018.

Miotti, H. (2009). *The Economic Impact of Standardization – Technological change, standards growth in France*. AFNOR report.

NBN. (2019). *Net Stock of Standards.* NBN.

North, D. C. (1991). Institutions. *The Journal of Economic Perspectives*, *5*(1), 97–112. doi:10.1257/jep.5.1.97

OECD. (2019). *OECD Compendium of Productivity Indicators 2019*. OECD Publishing.

OECD. (2019a). *National Accounts Database – Labour input by activity.* Retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE7A

OECD. (2019b). *National Accounts Database – Value added and its components by activity*. Retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE6A

OECD. (2019c). *Quarterly National Accounts.* Retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=QNA

OECD. (2019d). *Science, Technology and Patents database – Patents by technology.* Retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=PATS_IPC

OECD. (2019e). *STAN Industrial Analysis.* Retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=STANI4_2020

Padilla, J., Davies, J., & Boutin, A. (2017). *Economic Impact of Technology Standards*. Compass Lexecon Report.

Ramdani, D., van Witteloostuijn, A., Vanderstraeten, J., Hermans, J., & Dejardin, M. (2019). The perceived benefits of the European Union standardization. An exploration according to firm size and firm capabilities. *International Economics and Economic Policy*, *16*(2), 379–396. doi:10.1007/s10368-017-0391-5

Schwellnus, C., Pak, M., Pionnier, P.-A., & Crivellaro, E. (2018). *Labour share developments over the past two decades: The role of technological progress, globalisation and "winner-takes-most" dynamics.* OECD Economics Department Working Papers. No. 1503. OECD Publishing.

Standards Australia. (2012). *The Economic Benefits of Standardisation*. Research Paper Standards Australia.

Stokes, F., Dixon, H., Generosa, A. & Nana, G. (2011). *The Economic Benefits of Standards to New Zealand*. BERL Economics Report to the Standards Council of New Zealand and the Building Research Association of New Zealand.

Swann, P. (2000). The Economics of Standardization. Final Report for Standards and Technical Regulations Directorate Department of Trade and Industry. Manchester Business School.

Swann, P. (2010). The Economics of Standardization: An Update. Report for the UK Department of Business, Innovation and Skills (BIS). Innovative Economics Limited.

Temple, P., Witt, R., & Spencer, C. (2004). *Institutions and Long-Run Growth in the UK: the Role of Standards*. School of Economics Discussion Papers N1004, University of Surrey.

Zoo, H., de Vries, H. J., & Lee, H. (2017). Interplay of Innovation and Standardization: Exploring the Relevance in Developing Countries. *Technological Forecasting and Social Change*, *118*, 334–348. doi:10.1016/j.techfore.2017.02.033

ENDNOTES

[1]   This article is based on research in cooperation with NBN, the organization responsible for developing, publishing and selling standards in Belgium.

[2]   We focus on main contributions regarding the macroeconomic impact of standards. When multiple studies exist for a country we select the more recent and encompassing one. Keep in mind that these results are probably an underestimation as the studies only measure the impact of formal standards whereas more informal practices might also have an additional impact. See Padilla et al. (2017).

[3]   France, Germany, Italy and the UK. They build on previous work that focuses on Germany (Jungmittag et al., 1999)

[4]   Denmark, Finland, Iceland, Norway and Sweden, for diverse time periods starting between 1976 and 1997 until 2016.

[5]   Chemicals, Construction, Consumer, household appliances, and HVAC (Heating, Ventilation, and Air Conditioning), Digital Society, Electrotechnical, Energy and utilities, Food and agriculture, Healthcare, health and safety, Mechanical and machinery, Mining and metals, Services, defense and security, and Transport and vehicles. This sector classification is based on the sector division as used by NBN. However, slight adjustments had to be made to ensure compatibility with the OECD data.

[6]   More detailed information is included in the Table 6 in Appendix A.

[7]   Data on capital and employment retrieved from OECD (2019a, e). Capital employment ratio per person employed subsequently calculated.

[8]   Data on capital and employment in hours retrieved from OECD (2019a, e). Capital employment ratio per hour worked subsequently calculated.

[9]   Where NBN provided data on standards for most sectors, CENELEC provided data on standards for the sector electrotechnical.

[10]   Quarterly GDP retrieved from OECD (2019c).

[11]   As is shown in Figure 4, the sector electrotechnical has substantially more standards than the other sectors. Therefore, one might wonder whether these high values do not influence the results. Estimating the models of the next section without inclusion of the electrotechnical standards leads however to similar results.

[12]   The variable patents is measured as the number of patent grants at the European Patent Office (EPO), and is retrieved from the OECD Science, Technology and

Patents database (OECD, 2019d). The patents granted in Belgium, at the Benelux Patent Platform, are not included.

[13]   For more information on the impact beyond what is measured by the net stock of standards, see for example Blind & Jungmittag (2008) and Blind et al. (2011).

APPENDIX: ADDITIONAL INFORMATION

Table 6. Additional information regarding the source and measurement of the data

Variable Name	Measurement	Source – Database	Period
GDP	Output, euro, millions,2015	OECD – National Accounts Database	1995-2018
Employment	Total employment, persons, thousands	OECD – National Accounts Database	1995-2018
Hours worked	Total employment, hours, millions	OECD – National Accounts Database	1995-2018
Net capital stock	Volumes, euro, millions, 2010	OECD – STAN Industrial Analysis	1995-2016
Net stock of standards	Sum of all published standards up to the end of a specific year minus the sum of standards that has been withdrawn up to the end of that year	NBN CENELEC	1994-2019
Patents	Number of patent grants at the EPO	OECD – Science, Technology and Patents Database	1994-2018
Recession	GDP, US dollars, volume estimates, fixed PPPs, OECD reference year, annual levels, seasonally adjusted	OECD – Quarterly National Accounts	1994-2019

Source: Own compilation based on the dataset

Caroline Buts is professor at the Department of Applied Economics of the Vrije Universiteit Brussel. She specializes in competition policy, industry dynamics and defense economics.

Ellen Van Droogenbroeck (Doctor in Applied Economics: Commercial Engineer, Vrije Universiteit Brussel, 2018) is a guest professor at the Department of Applied Economics (APEC) of the Faculty of Economic and Social Sciences & Solvay Business School at the Vrije Universiteit Brussel (Free University of Brussels). Her current research interests include online grocery shopping, e-commerce, technology adoption, and color marketing.

Michaël Dooms (PhD Applied Economics: Business and Technology, VUB, 2010) is affiliated as associate professor with the Solvay Business School at the University of Brussels (VUB). At the VUB, he teaches courses in Management and Strategy, Organization Theory & Development, Micro-Economics of Competitiveness, and is responsible for the Internship program and the Foreign Trade Mission. He teaches port management courses in international programs at the Erasmus University Rotterdam at the Athens University of Economics and Business. He has worked as a project manager and researcher on several research and consulting projects, which need a multi-disciplinary (integration of technical, economic and environmental criteria) and multi-stakeholder (public and private sector, local communities) approach. As such, he has acquired an in-depth understanding of public/private sector interactions, as well as the governance mechanisms that lead to success in complex projects spanning the boundaries between public/private sector.

Kim Willems is professor marketing at the Vrije Universiteit Brussel (Belgium), in the faculty of Social Sciences & Solvay Business School, in the Business Department. She studies digitalization of retailing and services, focusing on the consumer- and company-perspective. Interdisciplinary improvements to the on- and offline shopping environment are focal. Her work has been published in (among others) Journal of Business Research, Psychology & Marketing, Journal of Services Marketing, Journal of Retailing & Consumer Services, Computers in Human Behavior, and Technological Forecasting & Social Change.