In search for a link between innovation, intellectual capital and company performance

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Abstract: The aim of the current paper is to explore the relationship between innovation/intellectual capital and the economic performance of firms in Flanders. For this purpose, use is made of a longitudinal firm-level dataset, built up by matching data from two different statistical sources: the Flemish CIS-3 (concerning innovation activities during 1998–2000) and a set of economic performance indicators drawn from the Belgian Belfirst (relating to the period 1998–2004). Our findings suggest that it is very difficult to make general conclusions on the relation between innovation and growth. In our sample, results depend on the definition of firm growth as a performance measure as well as on the method used to analyse the data.

Keywords: Innovation, Intellectual capital, Company performance

1. Introduction

The key role played by innovation in explaining the dynamic properties of firms, industries and economic systems has been acknowledged since the origin of economic thought, and is nowadays part of the general consensus among economists. It seems to be the (successful) introduction of product, process and organisational innovations that allows firms to override the pre-existing conditions of markets and industries, and to grow and gain market shares at the expense of non-innovating firms.

In general, also the academic research acknowledges that technological change and innovation are the major drivers of economic growth and are at the very heart of competition. Many studies find positive effects of innovation on economic performance (to name a few: Griliches, 1995, 1998; Lööf and Heshmati, 2001; Crepon *et al.*, 1998; Klomp and van Leeuwen, 1999; Evangelista, 1999; Kleinknecht and Mohnen, 2002; Kremp *et al.*, 2004).

It may be no surprise that, over the last few decades, a large body of literature on economic growth has attempted to account both theoretically and empirically for such a major issue in economic theory. However, in these studies, different perspectives and different approaches have been applied.

Studies differ with respect to the measurement of firm performance. Different concepts are used, ranging from (relatively) objective and measurable indicators or characteristics to subjective assessments based upon the company's (self-reported) ranking on a given performance index (Freel and Robson, 2004). Frequently used (economic) performance measures include growth rates of sales, total assets, total employment, cash flow, productivity or added value, and the return on investment. Alternatively, in order to allow comparison between firms of different sizes and sectors, growth in the sales per employee, export per employee, value added per employee, or cash flow on assets, are some of the indicators used.

With respect to the assessment of the innovation intensity, the literature provides us with several indicators. Traditionally and still the most popular input indicator is the expenditures on R&D (Klomp and van Leeuwen, 1999; Lööf *et al.*, 2001). Obviously, R&D has still a crucial role to play since it is an important factor that affects the development and introduction of innovation (Parisi *et al.*, 2005). Nowadays one witnesses an explosion of research on innovation and growth, often using new definitions and indictors of innovation. In brief, innovation indicators may be split up between macro, meso and micro level indicators on the one hand, and – when we distinguish between the three stages in the innovation process – between input, throughput and output indicators on the other hand.

An important initiative to measure and describe the innovation performance of firms in a systematic way is the Community Innovation Survey (CIS), a joint initiative of the INNOVATION programme and EUROSTAT. More specifically, the CIS is a large-scale survey designed for collecting quantitative data on the innovative behavior of firms and is carried out in many of the OECD member countries. The CIS is rooted within the so-called "Oslo Manual" which contains the OECD guidelines for collecting and interpreting data on technological innovation, and is based on a common, harmonized questionnaire and survey and applies commonly accepted definitions and indicators. The data collected in this way should allow for a more in-depth analysis and enhanced empirical basis to support innovation policy design in Europe.

The CIS collects data not just on R&D, but on a much wider spectrum of firms' innovation activities and sources of innovation, such as activities related to the design of new services, software development, the acquisition of know-how, investment in new machinery (ICT hardware) and training. Additionally, firms are asked to provide quantitative data on the financial resources devoted to these different activities. The first EU harmonized survey, entitled CIS-1, was launched in 1993. CIS-2 was executed in 1997. In the autumn of 2001, CIS-3 started. For Belgium, the CIS was organized by CFS-stat, that coordinates the activities of the different S&T statistics, and for Flanders[1], the Institute for the Promotion of Innovation by Science and Technology (IWT) was responsible for data collection. A descriptive analysis of the latest results of the CIS-3 data for Flanders is presented in Aerts (2005).

Despite the potential offered by this data source, only very few studies have so far used CIS data to explore the relationship between innovation and economic performance at the firm level. In particular in a Belgian (Flemish) context, no use has been made so far of the CIS-3 data in order to study the relation between innovative activities and firm performance. Some former studies based on Flemish CIS-1 or CIS-2 data only find a weak or no impact on performance measures as employment and added value (Abraham *et al*., 1998; Clarysse and Van Bierdonck, 1998; Clarysse and Uytterhaegen, 1999).

The aim of the current paper is to explore whether innovation has an impact on the economic performance of firms in Flanders. For this purpose, use is made of a longitudinal firm-level dataset, built up by matching data from two different statistical sources: the Flemish CIS-3 (concerning innovation activities during 1998–2000) and a set of economic performance indicators drawn from the Belgian Belfirst (relating to the period 1998–2004).

As basis for this research, we use the study of (a) Freel and Robson (2004), and (b) Van Cayseele and De Vil (1999). The former examine the effect of firm's innovation activities on their growth performance in a cross-sectional setting. The latter apply a panel data model, yet they only use a very rough innovation indicator to explore the link between innovation and economic performance in Belgium.

To investigate the relationship between innovation activity and firm performance, we apply several alternative measures of innovation and firm performance. This allows us to identify which of the different innovation indicators are most important in explaining the economic performance of firms. Making use of the Ordinary Least Squares (OLS) estimation techniques on the one hand, and of the random-effects GLS regression on the other hand, we find some interesting results.

The paper is structured as follows. In the following section we briefly present the model of (a) Freel and Robson (2004), and (b) Van Cayseele and De Vil (1999). Next, section 3 provides a brief description of the dataset. In section 4, the indicators used in the empirical analysis are defined. In section 5, we present the empirical results of the econometric analysis. In section 6, we comment on these results and discuss some limitations of the study. Finally, the last section synthesises the main empirical findings and draws some conclusions.

2. Model specification and estimation issues

Given the limitations of cross-sectional data analysis for drawing inferences about the influence of innovation on firm growth, we focus in this section on the panel data model. To study the determinants of growth for a sample of Belgian firms, Van Cayseele and De Vil (1999) apply and extend the model of Carpenter and Petersen (1998). The original model of Carpenter and Petersen relates the firm growth rate (growth in total assets) to the cash flow ratio. In this way, the influence of (eventual) financing constraints on firm growth can be investigated. Furthermore, in order to investigate the influence of innovation on firm growth, Van Cayseele and De Vil include the R&D-turnover ratio as an explanatory variable for firm growth and estimate the following model:

$$\text{Growth}_{kt} = \text{constant} + \beta_1 \text{ (Cash Flow / Assets)}_{kt} + \beta_2 \text{ (R\&D / Turnover)}_{k,t-1} + \varepsilon_{kt}$$

If a financing constraint exists, the cash flow coefficient (β_1) should be approximately one, i.e. in a firm with financing constraints, each additional dollar of internal finance allows one extra dollar of asset expansion. If the R&D coefficient (β_2) is positive significant, there is evidence that higher R&D expenses – serving as a proxy for innovation – lead to higher future growth, ceteris paribus.

Van Cayseele and De Vil (1999) find a positive but insignificant value for β_2. As an explanation for this (insignificant) result, they point at the accurateness of the reported data. Indeed, Belgian law gives no precise definition of R&D. Moreover, Belgian law allows for a "double" accounting treatment of R&D expenses: expensing or capitalization. For firms that opt for expensing R&D, there is no way to detect R&D expenses actually incurred, and the R&D-turnover ratio as measured by Van Cayseele and De Vil equals zero.

Furthermore, we want to point at the way innovation is measured by Van Cayseele and De Vil (1999). In the model, only R&D expenses have been taken into account. Albeit R&D represents a very important aspect of the innovation process, R&D investments are questioned as the sole driver of innovation. In other words, they only represent one of the possible indicators of innovation. Furthermore, several other weaknesses of this indicator can be mentioned (see Kleinknecht, 2000, for an extensive review). First, R&D is merely an input to the innovation process. Second, R&D-related inputs represent only a minority of innovation expenditures. Third, R&D data tend to underestimate innovations in services. Finally, R&D questionnaires underestimate the small scale and often informal R&D activities in smaller companies.

To obtain a more accurate estimate of the influence of innovation on growth, other measures for innovation should be considered in the above model. Research concerning the development of a correct measure for innovation of firms is a relatively young, expanding discipline. In the current study, we relate firm growth to some alternative / broader measures of innovation, next to the R&D-turnover ratio. These measures are derived from the literature on intellectual capital (IC), besides the literature on innovation. We relate these measures of innovation/IC to growth in total assets. In a second model formulation, we consider growth in sales (instead of growth in total assets) as the dependent variable, because sales growth is generally used in the innovation literature with the purpose of measuring the effectiveness of innovation.

Next to several innovation/IC indicators, we control for other determinants of economic performance, such as firm size and age and sector affiliation.

Notwithstanding the use of several alternative innovation and intellectual capital (knowledge) indicators, we are aware of the fact that we may not include an exhaustive list of the possible determinants of growth. As Freel and Robson (2004) mention in their study, modelling growth at the firm level is notoriously fraught. The factors conjectured to influence growth are numerous and their effect frequently inconsistent. As an example, Freel and Robson refer to the study of Westhead and Birley (1995), who identified 88 variables hypothesized to influence firm growth, but found that only 2 (in the case of manufacturing) or 3 (in the case of services) factors exerted a statistically significant influence on growth rates.

3. Data set

Our study is based on a longitudinal firm-level dataset built up by matching data from two different statistical sources. As a first data source, we use the third Flemish Community

Innovation Survey (CIS-3), conducted in 2001, which covers the innovation activities of 673 firms during the period 1998–2000. All companies covered by the survey have at least 10 employees, and are situated in diverse NACE industries. In the CIS-3, a multitude of alternative innovation indicators, each highlighting specific facets of innovation, are used to describe the multidimensionality of the firms' innovation performance. As pointed out, the indictors not only relate to activities aimed at generating new technological knowledge (for instance, R&D), but also to many activities aimed at the adoption and diffusion of technology (for instance, the purchasing of technologically new machinery and equipment, training and marketing activities necessary to introduce innovations, and so on). In fact, the database contains information on innovation input indicators, follow up investments as well as a number of output indictors. For a descriptive overview of the most important results from the CIS-3 data for Flanders, we refer to Aerts (2005).

Additionally, we use firm-level accounting data drawn from unconsolidated balance sheets, income statements and notes over the years 1998–2004. These data are drawn from the dataset Belfirst, which contains the annual report data of more than 300.000 Belgian firms and is made available by Bureau Van Dijk. For firms that publish an annual report according to the abbreviated scheme, however, some data (e.g. turnover) are not mandatory and hence missing in this dataset. Since the option was taken to eliminate any firm with one or more missing values (CIS-3 survey or Belfirst data), only firms publishing annual reports according to the complete scheme[2] are included in the sample. The advantage of this procedure is that we can estimate the different models using one sample.

In addition, some selection rules[3] are used in order to eliminate outliers.

Since only a relatively small part of the firms in our dataset is hold to publish an annual report according to the complete scheme, it is to be anticipated that missing data will be a serious problem in our analysis. In fact, after removing cases with missing observations (in particular for the turnover variable), the final sample consists of 259 firms. Only these firms have full data for the selected innovation indicators from the CIS-3, and the selected economic performance indicators for the period 1998–2004 from the Belfirst data (see section 5).

Table 1: Sample description

	Full sample (N=673)		*Sample after cleaning (N=259)*	
	Product Innovation	*Process Innovation*	*Product Innovation*	*Process Innovation*
*Firm Size**				
Small firms	43,3%	36,8%	77,8%	66,7%
Medium-sized firms	67,6%	60,7%	87,6%	75,3%
Large firms	67,9%	71,7%	80,6%	87,5%
Sector				
Low-tech	51,4%	56,8%	81,1%	81,1%
Mediumlow	53,2%	53,2%	87,2%	78,7%
Mediumhigh	60,8%	53,4%	81,8%	77,3%
High-tech	72,0%	64,0%	85,7%	78,6%
Knowledge intensive services	59,6%	44,2%	86,2%	65,5%
Other services	36,6%	31,1%	76,0%	70,0%

* small firms: 10–49 employees, medium-sized firms: 50-249 employees, large firms ≥ 250 employees

In view of the limited number of firms that have full data for the selected indicators, it can be expected that sample selection is possibly an issue. This, however, will also be the case in the study of Van Cayseele and De Vil (1999), since they also select only firms that publish an annual report according to the complete scheme. In Table 1, some characteristics of the full versus the final sample are shown. From this table, it appears that the percentage of firms in the final sample that is product / process innovative, is far more higher than in the full sample.

4. Variable description, measurement issues and persistency hypothesis

The variables used to measure corporate growth, internal cash flow generation and innovation/intellectual capital are presented in Table 2.

4.1 Growth (economic performance) indicators

In our analysis, we use two alternative growth performance indicators. Specifically, we measure growth in terms of the percentage change in (a) total assets and (b) turnover. These measures are relatively uncontroversial (methodologically) and data tend to be easily available. Both indicators are constructed from the Belfirst data, and hence are expressed in current prices. Although some indicators are also available in the CIS survey data relating to the period 1998–2000, we consistently opt for the use of the Belfirst data.

First, in line with Van Cayseele and De Vil (1999) and Carpenter and Petersen (1998), we apply growth in total assets as our basic growth indicator. Finding its origin in the cash flow constraints literature, this indicator is primarily used to investigate how growth (in total assets) relates to the availability of internal cash.

Additionally, we opt to apply an alternative growth indicator. In the innovation literature, sales growth is probably the most commonly used dependent variable in order to measure the effectiveness of innovation. It is indicative of increasing customer acceptance of the venture's product or service offerings and directly reflects the impact of introducing new products (goods or services). In this way, the advantage of this variable is the direct link between the innovation effort and the commercial success.

A brief description of both indicators is presented in Table 2.

Table 2: List of innovation performance and intellectual capital indicators

Variable	Definition
Economic performance indicators	
Growth in assets[a]	ln(change in assets)
Growth in turnover[b]	ln(change in turnover)
Financial constraint indicator	
Cash flow / Assets[c]	Ratio of cash flow over assets
Innovation performance indicators	
R&D / Turnover	Sum of internal and external R&D / turnover (in 2000)
Product innovation	Dichotomous variable, 1 for firms that have realized a product innovation in the period 98–00
Process innovation	Dichotomous variable, 1 for firms that have realized a process innovation in the period 98–00

Intellectual capital indicator (knowledge indicators)	
Highly educated personnel	Percentage of highly educated personnel (in 2000)
Training	Percentage of personnel involved in a training program (in 2000)
Patents	Dichotomous variable, 1 for firms which hold a patent (in 2000)
Control variables	
Age[c]	Age of the firm
Size of firm[c]	ln(number of employees)
Sector affiliation	Low-tech, Mediumlow, Mediumhigh, High-tech, Knowledge-intensive services, Other services

[a] For the OLS model, growth is defined as ln(mean assets during period 01-04) – ln(mean assets during 98-00); [b] For the OLS model, growth is defined as ln(mean turnover during period 01-04) – ln(mean turnover during 98-00); [c] For the OLS model, values are taken in 2000.

4.2 Financial constraint indicator

As pointed out, our econometric analysis is primarily based on the model of Van Cayseele and De Vil (1999). This model tries – besides the impact of innovation on growth – to find out whether the internal generation of cash flows is a determinant of asset growth. In a firm with financing constraints, each additional dollar of internal finance allows one extra dollar of asset expansion. Hence, a coefficient not statistically different from one is an indication of financing constraints.

In the model with sales growth, we also introduce the cash flow ratio as an explanatory variable, although the quantitative prediction (coefficient equals one in the presence of financing constraints) does not hold true in this model. We believe, however, that the availability of internal finance may be a determinant of sales growth if there are financing constraints, through the need to expand capacity in order to realize the growth in sales.

4.3 Innovation performance and intellectual capital (knowledge) indicators

In our model, we consider different dimensions of the firms' innovation performance. Therefore, we distinguish between innovation performance indicators and intellectual capital (or knowledge) indicators. Except for one variable (training), all variables are available from the CIS survey. As already pointed out, compared with the technological indicators more traditionally used in this field of research, the CIS data provide us with a much richer range of information on firms' innovation activities and performances.

A basic indicator provided by the CIS data, is whether the firm introduced an innovation in the period covered by the survey (1998–2000) and what type of innovation it was: a product (good/service) innovation (being defined as the introduction of a technological new or strongly improved product on the market) or a process innovation (being the introduction of new or strong improved production process).

The distinction between a product and a process innovation has long been recognised in the innovation literature as being crucial in order to identify the different strategies of firms. Product innovations are usually associated with more radical and proactive technological strategies, which are expected to bring high economic returns. Process innovations generally prevail in traditional industries and signal the presence of a more defensive technological strategy, often associated with rationalisation and restructuring processes (Cainelli *et al.*, 2006). Product and process innovations are distinct, in the sense that one of the two activities does not necessarily imply the other. In the sample of Parasi *et al.* (2005), for instance, only approximately half of the firms that did a process innovation also introduced a product innovation.

As one would expect, the productivity effect of a process innovation is larger than the one of a product innovation (Parasi *et al.*, 2005). Moreover, there are intriguing differences in the way in which R&D spending is related to the probability of introducing product versus process innovation. More specifically, R&D spending is generally associated with the introduction of a new product, but it is not a necessary condition for the introduction of a new process. The latter, on the other hand, is strongly associated with spending on new fixed capital, which may be consistent with an important role for embodied technological progress.

In our empirical analysis, we link the economic performance of firms to the realization of product and process innovation, and verify whether product or process oriented strategies lead to different economic outcomes.

Furthermore, we include the R&D-turnover ratio as an explanatory variable. A large body of literature has focused on the connection between spending for R&D and productivity growth (for an overview, see Mairesse and Sassenou, 1991). The empirical evidence, however, presents some mixed results. At the one hand, some studies have found that R&D's effect on productivity is essentially zero, while other studies exhibit a substantial positive effect. The same holds true for the effect of R&D on turnover. Van Cayseele and De Vil (1999) did not find any significant influence on growth in assets either, and so integrating the measure facilitates some comparison with their study. By using the CIS-3 data instead of the Belfirst data, we measure R&D expenses actually incurred accurately, since the Belfirst balance sheet only provides data on capitalized R&D.

Next, we introduce a second group of innovation indicators that can be described as intellectual capital or knowledge indicators. Knowledge, whether internally generated or externally acquired, is critical to the process of innovation. Furthermore, knowledge has been described as "the" critical resource that sets a firm apart from others (Spender, 1996). Knowledge assets may enhance a firm's chances of creating and implementing innovations. Tsai (2001), for example, found that internal units with higher levels of capabilities were more likely to introduce innovations than units with lower levels of capabilities. So whilst a positive relationship between knowledge and innovation can be proposed, knowledge can also affect firm performance (Thornhill, 2006).

The number of high-technology employees per firm, industry, cluster or region has been frequently used as a measure of the availability of human knowledge capital (DeCarolis and Deeds, 1999). In general, the concept of human capital pertains to individuals' knowledge and abilities that allow for changes in action and economic growth (Coleman, 1988). Consequently, human capital may be build up through formal training and education aimed at updating and renewing one's capabilities in order to do well in society (De Clercq and Dakhli, 2003), In our study, firm-level knowledge assets were operationalized as the percentage of the workforce that is highly educated. Although we are aware that a measure of full-time engineers and other specialists, responsible for identifying and implementing new technologies, conducting research, and leading the firm's training endeavours to secure competitive advantage, would be a better proxy, these data are not available in the CIS survey results.

Furthermore, we consider the number of employees that were involved in a training program during 2000 as a proxy for IC. This variable is not available in the CIS survey data, but is given in the social balance sheet[4] of the annual report.

Finally, we include the firm's patent status in our empirical analysis. Patents protect a firm's innovative output from imitation. In the literature, patents are often used as an (intermediate) output indicator of innovation (Kleinknecht, 2000). Albeit the use of patent data faces some well-known problems (e.g., Kemp *et al.,* 2003), the patent indicator has several important advantages. First, patent information is publicly available. Second, using citation analysis, one can assess the relative importance of patents. Furthermore, in a survey, the patent status can be easily asked for.

4.4 Control variables

Modern growth theory acknowledges that sector-specific technological regimes as well as possible structural differences between sectors (i.e., capital intensity, average R&D intensity,…) might translate in differences in the selected economic performance measures. This view, moreover, seems to be supported by empirical evidence, which suggests that not all sectors are equally innovative.

A common feature of the literature is the explicit or implicit focus on the manufacturing sector. Services for a long time have been seen as technologically backward with innovation playing only a marginal role in explaining the aggregate performance of this sector and the competitive strategies of firms (Cainelli *et al.*, 2006). However, over the last decade, a new stream of contributions to the literature has in fact begun to challenge the old view of services as being technologically backward or passive adopters of technology (e.g. Metcalfe and Miles, 2000, Gadrey and Gallouj, 2002, Tether, 2003). There is an increasing amount of empirical evidence to support this new perspective. For example, the results of CIS-2 confirm that innovation activities do occur in the services sector, though to differing extents and in various forms across industries (Eurostat, 2001). Also in the service sector, innovating firms out-perform non-innovating firms in terms of both productivity and economic growth (Cainelli *et al.*, 2006).

Although it is expected that innovative firms perform better than non-innovators, in the service sector as well as in the manufacturing sector, it also seems appropriate to make a distinction on the basis of the dynamism of the sector. Inventive output is higher in industries where knowledge develops rapidly and broadly, compared to more stable environments. In a dynamic industry, change is the norm. Firms must be innovative if they are to maintain the pace of change. In these conditions, one might expect non-innovators to fall behind. In stable environments, innovations may not be beneficial if markets are unwilling to depart from the status quo. In such environments, innovative firms may be put at a competitive disadvantage. Thornhill (2006) finds evidence of a positive relationship between industry-level dynamism and firm-level innovation. In particular, in the dynamic high-technology manufacturing sector, the percentage of firms introducing national or world-first new products was twice as high compared to the low-technology sector.

At the same time, however, the empirical evidence still remains inconclusive about what sector classification to use and how to construct and operationalize the indices applied (for a discussion, see Sandven *et al.*, 2005). Furthermore, using the Flemish CIS-3 data, Peeters *et al.* (2004) showed that, based on a simple NACE-code based classification, no compelling evidence exists of a clear-cut sectoral characterization of patterns of innovation. In addition, their results highlighted the co-existence of different innovation strategies within the same industry, which means that there are important degrees of freedom with respect to innovation strategies adopted by firms. In sum, these findings question to some extent the "sectoral determinism" suggested by Pavitt (1984).

In the current paper, we apply the OECD sector classification developed by Hatzichronoglou (1997) which distinguishes between industries in terms of R&D intensities (i.e., knowledge based approach). Instead of using the traditional categorization between high-tech and low-tech, which is built upon the premise that technology-intensive sectors are more growthinducing than low-tech sectors, this approach defines high- and low-tech more precisely by creating more categories. Additionally, this classification can be applied to services firms.

Specifically, a first distinction is made between the manufacturing sector (consisting of 4 sectors) and the services sector (2 sectors). Subsequently, the manufacturing sector is split up into low-tech, medium-low, medium-high, and high-tech sector. The services sector is split up into knowledge-intensive services and other services. The composition of these sectors in terms of their NACE codes, is given in the Appendix.

Additionally, our analytical model controls for the effect of firm age (years of operation) and size (log(total number of employees)) on firm growth. Age and size are typical control variables in studies of innovation, because larger, established firms have greater ability and strategic freedom than smaller, newly founded firms (Duysters and Hagedoorn, 2002). However, with size and age may also come rigidity and inertia that can negatively affect innovative activity and overall firm performance (Van de Ven *et al.*, 1999). According to Thornhill (2006), the impact of both variables does differ according to the sector they concern.

The basic descriptive statistics of the indicators used in our econometric estimates, are presented in Table 3.

Table 3: Economic and innovation performance indicators – descriptive statistics

Variables*	N obs.	Mean	Std.dev.	Min.	Max
Asset growth	259	0.13	0.39	- 0.892	1.19
Turnover growth	259	0.11	0.49	- 0.764	2.00
R&D/turnover	259	0.02	0.05	0	0.39
Product innovation	259	0.82	0.38	0	1
Process innovation	259	0.76	0.43	0	1
Highly educated per..	259	0.25	0.24	0	1
Training	259	0.34	0.37	0	1
Patent	259	0.27	0.45	0	1
Cash flow/assets	259	0.11	0.14	- 0.304	0.76
Age	259	27.84	19.63	5	103
Size	259	4.59	1.48	0	8.71
Low-tech	259	0.20	0.40	0	1
Mediumlow	259	0.18	0.39	0	1
Mediumhigh	259	0.25	0.44	0	1
High-tech	259	0.05	0.23	0	1
KI services	259	0.11	0.32	0	1
Other services	259	0.19	0.40	0	1

* As defined in Table 2 for the OLS model

4.5 Measurement issues and the innovation persistency hypothesis

Like all studies that use data from the CIS, we face some particular problems and data issues. An important issue is the fact that several innovation indicators from the CIS are related to a 3-year period. To give an example, in the survey, it is only asked whether firms realized a product innovation or not in the period 1998-2000, without specifying the precise moment of the product innovation. In view of the time lag between the introduction of a new product innovation on the market and the moment on which this translates in a better company performance, more precise information would be welcomed.

An important issue which receives great interest recently, is the innovation persistency hypothesis. This means whether firms innovate persistently or discontinuously over time. Albeit some mixed evidence is found, most studies seem to confirm the innovation persistence hypothesis. Based on the CIS-data for the period 1994-2002, a main finding of Peters (2006) is that both innovation input and output seems to a very large extent to be persistent over time. Furthermore, the author stresses the role of firm's innovative capabilities on the dynamics of their innovation behaviour. In particular knowledge provided by skilled employees was found to be an important factor for future innovation behaviour. Furthermore, Máñez Castillejo *et al.* (2004) find evidence that supports the hypothesis that firms are persistent with respect to their R&D activities.

In particular when performing the random effects GLS regression, we will apply the assumption of innovation persistency. In other words, we believe that a firm's innovative status (capabilities) will not change overnight. Instead, we assume that it is quite difficult for an innovator to lose suddenly all its innovative capabilities and to exhaust all its innovating opportunities. This implies that the innovation / intellectual capital variables which we observe only for the period 1998-2000, represent a stable proxy for the firm-level "innovation-culture/mentality" over the years 2001-2004.

5. Empirical results

5.1. OLS results

In a first attempt to explore the relationship between innovation and the economic performance of firms in Flanders, we apply Ordinary Least Squares (OLS) estimation. As in Freel and Robson (2004), we use the (innovation) data from the CIS-3 which is essentially cross-sectional. However, from the Belfirst data, we were able to extract economic performance data for the period 2001–2004 as well. This data hence is used to explore whether innovation and intellectual capital indicators (that refer to the period 1998-2000) have an impact on the economic performance of firms in terms of the mean growth in turnover and assets in the period 2001–2004 (see Table 2 for a description of the variables).

Table 4 exhibits the results of the OLS estimation for both selected growth indicators. Despite the low R^2s reported, which are to be anticipated given the high level of micro-noise inevitable in studies of this type, the models present some interesting results.

Table 4: Estimates of OLS models of the association between innovation activities with the performance indicators

Variables	Growth sales		Growth assets	
	β	t-value	β	t-value
Constant	- 0.2466	- 1.63	- 0.1343	- 1.09
Financial constraints				
Cash flow / Assets	0.1033	0.48	0.6052	3.46 [a]
Innovation performance				
R&D/turnover	1.3946	2.06 [b]	- 0.1145	- 0.21
Product innovation	0.1734	2.20 [b]	0.1023	1.60
Process innovation	- 0.0413	- 0.58	0.0086	0.15

Intellectual capital	0.3399	2.04 [b]	- 0.0005	- 0.00
Highly educated personnel	- 0.0324	- 0.34	- 0.0039	- 0.05
Training	- 0.0251	- 0.34	0.0629	1.07
Patents				
Control variables	- 0.0044	- 2.82 [a]	- 0.0024	- 1.90 [c]
Age	0.0668	2.61 [b]	0.0319	1.54
Size				
	0.0070	0.07	0.0151	0.20
MLowtech	- 0.0177	- 0.20	0.0202	0.28
MHightech	0.0120	0.08	- 0.0059	- 0.05
Hightech	- 0.2588	- 1.78 [c]	0.1588	1.35
Knowintserv	- 0.0659	- 0.67	- 0.0393	- 0.49
Othserv				
	0.1212		0.1038	
R^2	2.40 [a]		2.02 [b]	
F	259		259	
N				

[a] significant at 1% level; [b] significant at 5% level; [c] significant at 10% level

Considering the model which explains the growth in assets, we conclude that none of the innovation capacity / intellectual capital variables or sector dummies have significant explanatory power. Only firm age and the cash flow to total assets ratio are significant. The negative sign on firm age suggests that younger firms are associated with higher growth rates in assets, ceteris paribus. As in Van Cayseele and De Vil (1999), the coefficient on R&D-turnover ratio is positive but insignificant and the coefficient on the cash flow to total assets ratio is significantly positive but different from one. The latter finding suggests that the sample firms are not facing severe financing constraints.

A different picture arises when we consider sales growth as dependent variable. The results indicate that the R&D-turnover ratio, the product innovation indicator and the percentage of the workforce that is highly educated are all significant and positively related to sales growth. Process innovation is not significantly related to sales growth. The latter finding is not surprising, because this form of innovation is often associated with rationalisation and restructuring processes, and therefore does not influence the sales figure directly. The significant negative relation between age and firm growth is confirmed in this model. Results also indicate that firm size is significantly positively related to sales growth, indicating that larger firms realize higher growth rates, ceteris paribus. Also, firms in the knowledge-intensive service sector seem to perform worse in terms of sales growth compared to firms in the other sector classes, ceteris paribus.

5.2. Random effects results

In this section, we present the results when a panel data situation, as in Van Cayseele and De Vil (1999), is applied to explore the relationship between innovation / intellectual capital and firm performance. The results from the random effects GLS regression can be found in Table 5.

Considering the determinants of the growth rate in assets, the empirical results from the random effects GLS regression seem to support the results from the OLS analysis. Again, we notice that none of the innovation capacity / intellectual capital variable and none of the sector dummies are significant. The only significant explanatory variables are firm size and age. This suggests that younger/larger firms are associated with higher growth rates in assets, ceteris paribus. Again, the coefficient on the cash flow to total assets ratio is significant and positive. Yet, since it is different from one, we may conclude that no severe financing constraints exist.

Turning to the model with sales growth as dependent variable, we observe the positive significant effect of the R&D-turnover ratio and of the percentage of highly educated personnel on firm growth. This corresponds to the findings of the OLS model. Furthermore, we observe that the product innovation indicator appears to be not significantly related to sales growth. This contrasts with the results from the OLS model. The sign of the percentage of employees involved in training programs is negative significant. This finding seems to be counter-intuitive, since it suggests that the more the employees are involved in training, the lower the growth rate in sales is. A possible explanation may be that training is likely to take place in years of restructuring. Like the OLS results, the random effects GLS regression results indicate a significant negative relation between age and sales growth and a significant positive relation between size and sales growth. Also, confirming the OLS results, firms in the knowledge-intensive service sector seem to perform worse in terms of sales growth compared to firms in the other sector classes, ceteris paribus.

Table 5: Estimates of random effects models of the association between innovation activities with the performance indicators

Variables	Growth sales		Growth assets	
	β	z-value	β	z-value
Constant	- 0.1542	- 3.29 [a]	- 0.0384	-1.24
Financial constraints				
Cash flow / Assets	0.4220	8.86 [a]	0.2955	7.78 [a]
Innovation performance				
R&D/turnover	0.5210	2.41 [b]	- 0.0421	-0.30
Product innovation	0.0246	0.98	0.0159	0.97
Process innovation	- 0.0109	- 0.49	0.0102	0.70
Intellectual capital				
Highly educated personnel	0.1099	2.11 [b]	0.0089	0.26
Training	- 0.0510	- 2.05 [b]	- 0.0015	-0.08
Patents	- 0.0146	- 0.63	0.0201	1.33
Control variables				
Age	- 0.0017	- 3.51 [a]	- 0.0007	-2.44 [b]
Size	0.0392	5.03 [a]	0.0107	2.01 [b]
MLowtech	0.0030	0.10	- 0.0009	-0.05
MHightech	- 0.0172	- 0.60	- 0.0088	-0.48
Hightech	- 0.0223	- 0.47	- 0.0283	-0.91
Knowintserv	- 0.0994	- 2.14 [b]	0.0305	1.01
Othserv	- 0.0051	- 0.17	- 0.0114	-0.56
R^2 (overall)	0.07		0.05	
N	1545		1545	

[a] significant at 1% level; [b] significant at 5% level; [c] significant at 10% level

6. Remarks and limitations of the research

When reference is made to the time period of our dataset, it is clear that we allow for lags in the relationship between innovation / intellectual capital and firm performance. We posit that innovation activities performed from January 1, 1998 to December 31, 2000, have their main impact on performance in the period 2000–2004. This is a relatively plausible assumption, given that innovation efforts require some time to translate into innovative output and productivity advances. But it cannot be ruled out that innovations may have a faster or a slower impact. Slow-impact projects may only have their (main) impact after 2004. In that case, the empirical results will underestimate the impact of the innovation efforts. On the other hand, we may be measuring the results of innovation efforts made before 1998. While indicators of economic performance are available for the whole time span of 1998-2004, the CIS-3 survey only provides us with innovation indicators for the year 1998–2000.

In particular when performing the random effects GLS regression, we apply the assumption of innovation persistency. In other words, we believe that a firm's innovative status (capabilities) will not change overnight. Instead, we assume that it is quite difficult for an innovator to lose suddenly all its innovative capabilities and to exhaust all its innovating opportunities. This implies that the innovation / intellectual capital variables which we observe only for the period 1998-2000, represent a stable proxy for the firm-level "innovation-culture/mentality" over the years 2001-2004. Given the mixed empirical results that can be found in the literature with respect to the presence of innovation persistency, this might be a very strong assumption for the Flemish case.

The causality direction between performance and innovation is another issue that has been extensively studied in the innovation literature. Already in 1942, Schumpeter argued that the increasingly scientific base of economic activities causes innovation to become more and more costly, as a result of indivisibilities and significant economies of scale and scope. The funding of risky, long-term and large-scale innovation projects requires substantial financial resources and is facilitated by healthy economic track records from firms that are associated with high growth rates, large profits and healthy cash flows. Some studies (e.g. Cainelli *et al.*, 2006) take into account the feedback loop from economic performance to innovation performance. Cainelli *et al.* (2006) find evidence of past economic performance being an important determinant of innovation activity. In our study, we do not test for the existence of structural associations between innovations and past economic performance.

A final comment relates to our sample used. As mentioned, only the firms publishing annual reports according to the complete scheme – i.e. large firms - are included in the sample. So the sample may not be representative of the population of Belgian firms. Besides, there is a potential survival bias due to the fact that we do not allow for missing values (i.e. only those firms with complete data for the selected indicators for the period 1998-2004 are retained).

7. Conclusions

The aim of the current paper is to extend our knowledge of the relationship between innovation / intellectual capital and firm performance. As basis for this research, we use the study of Freel and Robson (2004) who examine the effect of firm's innovation activities on their growth performance in a cross-sectional setting. Next to this, we apply the panel data model, as an extension to the study by Van Cayseele and De Vil (1999).

To investigate the relationship between innovation activity and firm performance, we apply both growth rate in sales and growth rate in total assets as measures of firm performance. Additionally, we integrate several new indicators of innovation / intellectual capital (compared to Van Cayseele and De Vil, 1999).

Based on a sample of 259 Flemish firms, and after controlling for firm size and age, our findings suggest that some indicators of innovation capacity and intellectual capital are significantly related to the growth rate in sales, but not to the growth rate in total assets. In all, this suggest that it is very difficult to make general conclusions concerning innovation and growth.

Given the importance of the subject, and its limitations, further research is needed. An interesting new pathway for the future is the so-called CDM model (see Lööf and Heshmati, 2002 and 2006), which analyses simultaneously the propensity to invest in innovation activities, innovation input, innovation output and productivity. In this way, the estimation procedure accounts for both selectivity and simultaneity biases.

Notes

1. Flanders is the Northern, Dutch-speaking part of Belgium.
2. In Belgium, firms are no longer allowed to lay down an annual report according to the abbreviated scheme if they have more than 100 employees, or if they exceed two of the following three criteria: a turnover of 7.000.000 euro, assets of 3.500.000 euro, or 50 employees.
3. Firms were eliminated in the following situations:
   - the percentage of the workforce that is highly educated > 1
   - the percentage of the workforce involved in training programs > 1
   - the R&D / turnover > 0.75
   - the average growth rate in sales > 2 (mean for the period 98-00 or 01-04)
   - the average growth rate in assets > 2 (mean for the period 98-00 or 01-04)
4. In Belgium, the social balance sheet is included in the notes to the financial statements. It is meant as an information source for the government concerning all kinds of data with respect to the workforce.

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Appendix

Manufacturing and services classification (NACE codes)

I. MANUFACTURING	
LOWTECH: Low-technology	Other manufacturing and recycling (36-37); Wood, pulp, paper products, printing and publishing (20-22); Food, beverages, tobacco (15-16); Textile and clothing (17-19)
MLOWTECH: Medium-low-technology	Coke, refined petroleum products and nuclear fuel (23); Rubber and plastic products (25); Non metallic mineral products (26); Shipbuilding (35.1); Basic metals (27); Fabricated metal
MHIGHTECH: Medium-high-technology	Electrical machinery (31); Motor vehicles (34); Chemicals (24 excl. 24.4); Other transport equipment (35.2+35.4+ 35.5); Non-electrical machinery (29)
HIGHTECH: High-technology	Aerospace (35.3); Pharmaceuticals (24.4); Computers, office machinery (30); Electronics-communications (32); Scientific instruments (33)
II. SERVICES	
KNOWINTSERV: Knowledge intensive services	KNOWLEDGE-INTENSIVE HIGH-TECH SERVICES Post and telecommunications (64); Computer and related activities (72); Research and development (73) KNOWLEDGE-INTENSIVE MARKET SERVICES Water transport (61); Air transport (62); Other business activities (74) KNOWLEDGE-INTENSIVE FINANCIAL SERVICES Financial intermediation, except insurance and pension funding
OTHSERV: Other services (knowledge in-intensive)	Wholesale (51); Land transport, transport via pipelines (60); Supporting and auxiliary transport activities, activities of travel agencies (63)