Bachelor Thesis Science & Innovation Management

Testing the Varieties of Capitalism theory; an analysis of radical and follow-up patents

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Abstract

This study tested the claims made in Hall & Soskice's (2001) Varieties of Capitalism (VoC) theory that the institutional context in which Liberal Market Economies (LME) solve their coordination problems, causes them to be more favourable for high-tech industry and radical innovation specialisation than Coordinated Market Economies (CME). This was done by analysing the origin and radicalness of the ten most-cited patents and their 50 first follow-up patents in the high-tech Office, Accounting and Computing Machinery (OACM) sector. It was shown that the distribution of patents is more strongly concentrated towards LMEs. Using a novel method of measuring radicalness based on the distance between technology fields, it was found that in stark contrast with VoC theory's claim, most of the patents were incremental. Using the number of inventors as an indirect indicator for radicalness, it was found that the majority was radical. All in all, only partial support for VoC theory was provided by the findings and the use of citation count as an indicator for radicalness was called into question.

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1. Introduction

Radical innovation is important for economic growth as it drives the creation of new products and businesses. Whole industries can spring up when markets are opened up by radically new ideas and products (Mokyr, 1990). The true nature of radical innovations is still unknown, however in the past it was thought to be the simple culmination of being the right person at the right time and place. Presently more is known about what exactly constitutes these right people, times and places. Understanding where radical innovations come to fruition, and more importantly why they come to the fore in certain places, is important because it can help managers and policy makers make more informed decisions about the future.

One driver for higher innovative output is comparative advantage. Ricardo (1817) argues that some firms have greater growth than others because they have a comparative advantage over them. He says that due to differences in factor endowments and technological progress some firms are better or cheaper in comparison to their competitors and gain an advantage over them, thus allowing them to grow bigger at the expense of other firms. Porter's *Competitive Advantage of Nations* (1990) added to this by introducing institutions to the theory. He says that institutions also play an important part in a firm's or nation's ability to gain an advantage. Even greater importance is placed on institutions by Hall & Soskice (2001) in their Varieties of Capitalism theory. They state that institutions act as a selection environment for complementary institutions and eventually for whole industry sectors. This implies that firms can acquire a comparative advantage not only through favourable factor endowments like availability of natural resources, but also through favourable institutions like easy access to finance or workers. In cases where multiple firms enjoy more or less equal factor endowments, one could still rise above the others when it enjoys benefits from complementary institutions.

Previous studies (Hall & Soskice, 2001; Hall & Gingerich, 2009) have argued that there is a connection between different varieties of capitalistic systems and the different kinds of innovations they produce due to their respective comparative advantages. There have been studies supporting this theory (Akkermans et al., 2009; Schneider & Paunescu, 2012; Meelen, 2013) but also studies criticising it (Kang, 2006; Taylor, 2004; Campbell & Pedersen, 2007).

The theory purports that due to the prevalent institutions that govern a country, countries characterised as Liberal Market Economies (LME) specialise in high-tech sectors based on radical innovations. Whereas countries characterised as Coordinated Market Economies (CME) specialise in medium-tech sectors based on incremental innovations. This spread should be observable in the number of patent applications and citations. It seems however, that the ten percent most radical innovations appear to be randomly distributed across LMEs and CMEs (Meelen, 2013). This discrepancy between the theory and practice is called the VoC paradox.

Contrary to the predictions of VoC theory, high-tech industry specialisation in LMEs is not based on the LMEs' capacity to generate more radical innovations within that industry. Radical innovations within high-tech and medium-tech industries take place at random in LMEs as well as CMEs. These results suggest that while radical innovations occur at random within the high-tech and medium-tech industries of LMEs as well as CMEs, their use in later patent applications is determined by the institutional contexts prevailing within LME and CME nations.

A problem that has arisen is that different studies use different concepts on which they base their analyses, resulting in a fragmented area of literature. Meelen's (2013) review of the literature base shows that though a consensus exists regarding some areas of the theory other areas are still contested. This is mainly caused by differences in conceptualisation and operationalisation of the concept 'comparative advantage' (Meelen 2013). Akkermans et al. (2009) for example shift the focus point from nations to sectors. In VoC theory industries are seen as either entirely radical or entirely incremental. Akkermans et al. (2009) say that this is wrong because all industries produce both radical and incremental innovations, and therefore look at innovation strategies within sectors instead of within countries.

The VoC theory has a theoretical foundation based on comparative case studies; however, due to the contradictory results of empirical studies testing the theory a gap in the literature exists. Due to these contradictory results it is unclear whether the theoretical grounding is strong enough to be used as a basis for further research and policy. VoC theory has been used as a basis for other studies as well as for policy making purposes (Hancke et al., 2007). Because this can have far-reaching consequences the theory must be continually and critically examined to ensure it is sound enough to be used in such a way.

This study aims to add to the knowledge base concerning the Varieties of Capitalism theory by analysing both radical and incremental patent claims to determine whether or not they exhibit the industry localisation and specialisation patterns as described by the VoC theory.

All studies testing the VoC theory have been based on such patent claims, however the issue has arisen that there is no single indicator by which the radicalness of patent claims can be measured. Since this building block on which these studies have built is not properly identified, the studies may have been miscategorising certain patent claims, leading to wrong conclusions about the VoC's claims.

This is why by descriptively analysing the patents on a number of radical innovations and their follow-up innovations, this study aims to better explore and define the radicalness of said patents. The relationship between these patent claims and their countries of origin is also examined. This can help clarify some hazy areas left in the theory, such as were the current contradictory results stem from, by adding more data to the current knowledge base. This is a bottom-up, data exploration driven study to see what patterns can be discerned in patent applications made in the high-tech Office, Accounting and Computing Machinery (OACM) sector, to see whether the claims made in the VoC theory stand up to scrutiny. Therefore, the following research question is asked in this study:

To what extent are LMEs due to their institutional contexts more favourable for high-tech innovation development in the Office, Accounting and Computing Machinery sector than CMEs?

To answer this question the findings of this research are contrasted with the predictions from the VoC theory so that more insight can be gained into the reason why the VoC paradox exists and how it could be resolved.

In the following section the relevant theoretical framework concerning the Varieties of Capitalism theory is described, as well as the literature concerning patents and their use in research. A novel method of measuring radicalness based on technological difference is also explained in detail. Following that, the methodology with respect to the research design, the methods of data collection, and the analysis is elaborated upon. In the section after that the results are presented and provided with an interpretation. These results are then followed by a discussion of their implications, especially concerning the use of patent data as an indicator for innovativeness, and the limitations of this study. Lastly, the final results are summarised and presented with a conclusion.

2. Theory

In this section the relevant theoretical framework concerning the Varieties of Capitalism theory is explained in detail as well as the use of patents in information diffusion studies.

2.1 Varieties of Capitalism

Varieties of Capitalism is a theory set forth by Hall and Soskice (2001) that purports that in accordance with the way coordination problems are solved within capitalist countries, they can be categorised as being a member of one of two groups; a Liberal Market Economy (LME) or a Coordination Market Economy (CME). In a liberal market economy firms coordinate their activities primarily via hierarchies and competitive market arrangements. In coordinated market economies firms depend more heavily on non-market relationships to coordinate their endeavours with other actors, and to construct their core competencies (Hall & Soskice, 2001).
The countries in each group solve their coordination problems similarly because they have similar institutions, such as laws, traditions, and codes of conduct (North, 1991). According to VoC theory, the different qualities that the two types of economies exhibit make that they act as selection environments for innovations. It says that because LMEs are more geared towards high risk-high gain, short-term partnerships there is a bigger focus on the generation of new radical ideas. This leads to a specialisation in high-tech sectors. CMEs on the other hand lean towards long-term cooperation and risk management and as such there is more of a focus on incremental innovation. This leads to a specialisation in medium-tech sectors (Hall & Soskice, 2001).

Hall & Soskice originally categorised 16 countries as either LME or CME. Over the years several studies have used Hall & Soskice's criteria to add more countries to that list (Witt & Redding ,2012; Tylecote & Visintin, 2007; Schneider & Paunescu, 2012). Because this study aims to test Hall & Soskice's original claims, the original 16 countries are used.

Liberal Market Economy	Coordinated Market Economy
USA	Germany
UK	Japan
Canada	Switzerland
Ireland	the Netherlands
New Zealand	Belgium
Australia	Sweden
	Norway
	Denmark
	Austria
	Finland

Table 1. Hall & Soskice's (2001) original categorisation.

2.1.1 Five spheres

Hall & Soskice (2001) identify five spheres in which firms develop relationships to resolve coordination problems central to their core competencies (Hall & Soskice, 2001). Although the theory is firm-centric, it generalises the way individual firms conduct business to the national level. This is possible because the behaviour of a country can be described as the outcome of all behaviours of firms (Porter, 1990). That is why these spheres reflect a country's institutional structure and help explain why different countries specialise in different forms of innovation. These spheres are: Industrial relations, Vocational training and education, Inter-firm relations, Corporate governance, and Employees.

Industrial relations

Industrial relations is the sphere which is concerned with the coordination of bargaining over wages and working conditions. The relations can be with the firm's own labour force, labour representing organisations such as unions, or other employers. The wages and productivity levels that come out of the negotiations affect the success of the firm and the rate of employment of the economy taken as a whole (Hall & Soskice, 2001).

In CMEs the labour force and unions tend to be more organised and wield considerable power as a result. This makes it difficult to fire employees and job tenures are longer on average because of it (Meelen, 2013). Because workers are longer with a single firm, they acquire more firm-specific competences. Also, because of the extra job security workers are more comfortable with suggesting small improvements to the firm's products and processes. This fosters incremental innovation (Meelen, 2013).

In LMEs the labour laws are less strict and the labour market is more fluid. This allows firms to attract, and subsequently dismiss, employees from various different backgrounds on short notice. Another factor is that employers enjoy more power due to lack of coherence in labour organisations. This allows top management to execute radical changes in their firms and the organisation of the firms without encountering much resistance from unions or employees (Lehrer, 2001). This stimulates short-term high-risk radical innovation projects (Hall & Soskice, 2001).

Vocational training and education

Vocational training and education is the sphere that deals with the problems firms on the one hand face with acquiring a workforce having suitable skills, and workers on the other hand face with deciding in what skills to invest their time and attention. The answers to these problems affect both individual companies and workers, and the competitiveness and skill levels of the whole economy.

In CMEs workers tend to train in firm- or industry-specific skills through internships or apprenticeships. Education focusses on in-depth knowledge earlier in the study than occurs in LMEs. These specialised skills allow the workers to better make incremental improvements to current products.

In LMEs a larger emphasis is put on a broad education and the acquisition of general skills. Competences that will not only be useful in a person's first job, but in all subsequent jobs too. Because workers have knowledge of a wide variety of fields they are better able to bring together insights from different areas and create new products, i.e. radical innovations (Hall & Soskice, 2001).

Inter-firm relations

Inter-firm relations is the sphere in which firms form relations with other firms in order to secure demand for its products, appropriate supplies of inputs, and access to technology. The coordination problems that arise in this sphere come from the sharing of proprietary information and the risk of asymmetrical learning and exploitation in joint ventures. The firm's capacity to stay competitive and the whole economy's technological progress depend on the ability to develop appropriate relations (Hall & Soskice (2001).

Collaborative relations between firms such as strategic alliances can help firms engage in bigger and longer projects by diversifying their risks and allowing them to tap into larger pools of knowledge and capital. These collaborations are stimulated in CMEs because they produce innovations that individual firms could not have made on their own. Because firms in these types of partnerships work together closely they build up trust between each other. Thanks to this trust they are comfortable working together for long periods of time, leading to the production of more incremental innovations.

Competitiveness on the market is considered extremely important in LMEs. This competitiveness is stimulated by anti-trust laws so that competition-destroying cartels cannot appear. A consequence of this is that partnerships and other inter-firm collaborations are highly regulated through contracts and often on a short-term basis only. Something that can happen is that instead of partnering up, large firms simply buy small, radically innovative firms. Because of this, firms only collaborate when the knowledge they need is too far from their own expertise to acquire on their own. When collaborations from two very different technology fields merge they often lead to radical innovations (Meelen, 2013).

Corporate governance

Corporate governance is the sphere that deals with the problems that firms face in securing finance and the assurance of returns on investments that investors seek. The starting of new projects by firms and the starting of new firms in general to continue the dynamics of the economy as a whole, depend on firms being able to acquire sufficient funding (Hall & Soskice (2001).

In CMEs banks and the government provide patient capital, often on the basis of trust. These long-term loans, which are given on the promise of revenue in the long run, give firms the financial stability and time to produce incremental innovations, so as to secure long-term stable profits for both parties.

In LMEs financing is mostly done via equity markets. Investors use publicly available data to decide whether or not to invest in a business. This means that generally only firms that are currently profitable can attract funds. Firms are therefore less likely to focus on long-term investments and incremental innovations, and more on short-term and radical innovations as a result (Meelen, 2013).

Employees

Employees is the sphere that governs all coordination problems related to firm-employee interactions. It is concerned with ensuring that the employees have the requisite competencies and stimulating cooperation amongst them to further the firm's objectives. The relations firms develop reflect on their own competencies and the production regime of the economy as a whole (Hall & Soskice, 2001).

In CMEs the collaborative mindset of employees makes that they tend to cooperate more easily with each other. This means that information is more rapidly shared and that interpersonal problems are dealt with in a professional manner. Thanks to this workers tend to stay longer with the firm, develop firm-specific skills and contribute to the firm's success in the long run. This stimulates incremental innovation as was mentioned earlier in the Industrial relations sphere.

In LMEs workers have more competitive mindsets. They are valued on their unique competencies and as such are less inclined to share information in fear of losing their edge and being replaced by someone with better skills. On the other hand, it does stimulate the workers to acquire new skills and do their best for the firm to prove their worth. In doing this they add to the firm's total competence base and increase the likelihood of producing radical innovations (Meelen, 2013).

2.2 Additions to VoC theory

Meelen (2013) and Akkermans et al. (2009) have tested the claim that radical innovations occur mostly in LMEs. They found that the top 10% of patent applications for radical innovations are randomly distributed across both LMEs and CMEs. Meelen argues that an explanation for the difference between these findings and the findings from Hall & Soskice may be that institutional contexts in LMEs select the randomly occurring patent claims for those that will result in radical follow-up innovations.

Singh & Fleming (2010) studied who the inventors of breakthrough innovations were. They found that people that work together in groups are more likely to come up with a breakthrough innovation than individual inventors. This implies that innovations made in LMEs are more often made by groups than individuals, since LMEs are more likely to produce radical innovations (Hall & Soskice, 2001).

2.3 Radical versus incremental patents

Hall and Soskice based their research on patent claims, as did many before them and many after them (Webb et al., 2005; Archibugi & Planta, 1996; Jaffe et al., 2000). That is why it is necessary to take a step back and investigate the implications that this presents. It is also important to properly define when a patent is considered 'radical' in this study.

When an invention is patented the developer is protected against others using the technology without permission. This give firms the time to fully exploit an invention and get a return on their investments in R&D. They enjoy the first-mover advantage; they are able to tap into an unspoiled market and make their name synonymous with the product, and they are able to build up their competencies in production and logistics. This gives firms an incentive to innovate because they can be sure to make a profit.
A patent claim provides data on a number of things. It states the inventor and his country of residence, the applicant and his country of residence, its classification, previous patents on which it builds, and a short description of the claim.

When an applicant files a patent claim he has to list all the prior patents on which it was based. This is called backwards citation. If the prior patents are from different patent families, as categorised by the International Patent Classification (IPC), the patent claim can be said to be radical because it combines knowledge from very diverse technology fields. A patent can also be called radical when it has been referred to, or forwardly cited, a lot. After all, if it had an impact on many patents claims after it, it must have been an important building block for many new innovations (Dahlin & Behrens, 2005). That is why many studies use citation count as a criterion for radicalness (Trajtenberg, 1990). On the other hand, this could also mean that the technology could easily be implemented into other applications because it wasn't that unrelated at all. This implies that the patent could have been incremental instead of radical (Marco, 2007).

Because of this ambiguity arguments have been made for the addition of economic impact as an indicator of the radicalness of an innovation. However, this addition raises some issues itself. Consider the following: An innovation that builds on previous products is released and has a profound impact on the market through a combination of clever marketing and sheer luck. Because of its impact it could be classified as a radical innovation, even though technologically it might have been called incremental. The inverse could also happen. A product could be so radically innovative that the market or industry simply isn't ready for it and it does poor commercially as a result. How then should this product be classified? As radical based on its technological merits? Or as incremental due to its commercial failure?

Meelen's (2013) tested this argument and found no supporting results for the inclusion of economic impact to the definition of radicalness. He hypothesised that this can be explained by the VoC theory's main arguments. The theory focuses on product development as a sign of sector specialisation brought about by a certain institutional context, not on economic activity.

A problem that hasn't been touched upon in either Hall & Soskice (2001), Meelen (2013), or Akkermans et al. (2009) is the issue of how radical patent claims are. The studies made a radical/not-radical dichotomy that doesn't allow for any grey areas in between. No measure of the 'amount' of radicalness has been proposed yet.

This study proposes a way to estimate the radicalness of a patent claim. Radicalness is measured on a four point scale normalised to 1 to provide a framework along which patents can be objectively compared. This scale measures the technological diversity by comparing patent classifications by breaking the IPC codes down into their components and scoring them on level of difference. Patents that score less than 0.4, meaning that they are less than 40% different from their cited patent, are deemed incremental. Those that score more than 0.6 are deemed radical. Those that score between 0.4 and 0.6 are marked as undetermined due to ambiguity.

2.4 Hypotheses

The OACM sector is a high-tech sector, a sector LMEs specialise in. So it follows that innovations made in the OACM sector are more often concentrated in LMEs. Following Hall & Soskice it is hypothesised that:

H1.1: The top 10 most-cited patent applications originating in the high-tech OACM sector are geographically concentrated in LMEs.

Following Meelen it is further hypothesised that:

H1.2: The first 50 follow-up patent applications originating in the high-tech OACM sector are geographically concentrated in LMEs.

Again, since the OACM sector is one in which LMEs specialise, and more radical innovations come from LMEs, it follows that patents applied for in the OACM sector should score 0.6 or higher. This implies that:

H2.1: The most-cited patent claims applied for in the high-tech OACM sector score >0.6

H2.2: The follow-up patent claims applied for in the high-tech OACM sector score >0.6

Again, the OACM sector is one in which LMEs specialise. Following Singh & Fleming that more breakthrough innovations are made by teams, it is theorised that innovations made in the OACM sector are more often made by groups than by individuals. Therefore:

H3: Patent applications made in the high-tech OACM sector are mostly made by multiple inventors.

Espacenet provides the countries of residence of the inventor(s) and the applicant, which is usually the firm the inventor is linked to. Because this study is most interested in the institutional context in which the idea that lead to the patent application was conceived and developed, the location of the inventor is taken. It is theorised that inventors usually live and work in the same country and that the inventor/applicant distinction is therefore of no impact on the data. In order to be sure the following hypothesis is tested:

H4: The country of residence of the inventor is identical to the country of residence of the applicant.

Answering these hypotheses contributes to answering of the research question. If evidence is found in support for hypotheses H1-H2, that would directly underpin VoC theory's claims that LMEs are more favourable than CMEs for radical innovation development in high-tech sectors. Evidence found in support of H3 would strengthen this. Evidence found in support of H4 gives support to the analysis method used in this study, providing greater internal validity.

3. Methods

To investigate where radical innovations occur and whether their eventual use is selected by institutional contexts, a selection of patent claims is thoroughly analysed. Patents have often been used as a measure of innovativeness and this research continues in that tradition.

3.1 Research design

In this study is chosen for a cross-sectional design in order to provide a rich and in-depth exploration of the attributes and characteristics of radical and incremental patent claims placed in the context of their technology fields. The goal of this research is to test hypotheses on which further theory can be build. To do this technological distance scores and distributions of locations are quantitatively analysed.

3.2 Data collection

In order to accurately analyse the patents, selections have been made. This study focuses on the Office, Accounting and Computing Machinery (OACM) high-tech sector. The reason this sector is chosen is that is it high-tech in nature (WIPO, 2015). To further narrow it down the ten patents that have had the most impact, based on citation count, are chosen as radical patents. Because one radical patent might have hundreds of follow-up patents, the first follow-up patent applications, with a maximum of 50, have been chosen because they are most likely to provide interesting data. This maximum is set due to time constraints.
As a time frame the most radical patents from 2010 are chosen. The follow-up patents can range until the present day. This is done so that there has been enough time for the radical patent to permeate through the industry and generate follow-up patents, whilst still being recent enough to be correlated with current institutions and LME/CME categorisations.
The patents are analysed on geographical location of the inventor(s) and applicant(s), and radicalness. The patent data is drawn from the international Espacenet database.

Citation count is used as a selection criterion for the most radical patents. As was mentioned earlier, this is the simplest and most used indicator for patent radicalness. This study follows the same method as other authors; the higher the citation count, the more radical the patent. The most-cited patents are selected as most radical patents for further analysis. The reason this method is used as opposed to this study's own proposed method is because it is absolute, whereas the new method is comparative. That is to say, the newly proposed method needs a baseline against which to compare other patents. If this baseline doesn't exist, it is not be able to provide results. The citation count method does not suffer from this issue and is therefore used. Once the patents have been selected the new method is used to ascertain whether they were in fact radical.

3.3 Analysis

To investigate hypothesis 1 information about the location where the patents were applied for is collected from the patent data under the header 'inventor'. The patents are then split into the three categories of LME, CME, and Other. The patents are then descriptively and quantitatively analysed by most-cited patent (MCP) and follow-up patent (FUP) in order to discern any patterns in locales.

For hypothesis 2 the technological distance is measured along the four point scale normalised to 1 as described earlier in the theory. Similar to hypothesis 1, the scores are quantitatively analysed by MCP and FUP. Each patent is assigned a classification code by the international patent office. This IPC code is based on the technology field in which the invention falls. The code classifies the invention in increasing levels of detail in: Section, Class, Subclass, Group, and Sub-group. The distance between technology fields is measured by comparing the level at which the codes differ.
An example of a patent classification looks like this: B07C2230/00 [colours added]. If the sections (the first letter marked in red) differ the technological distance is regarded as maximal and a score of 4 is awarded. If the sections are the same but the classes (the next two digits in blue) differ a score of 3 is given. The same goes for the sub-classes (the next letter in orange) with a score of 2, and again for the groups (the next digits in green) with a score of 1. The sub-groups (the final digits in purple after the forward slash) are not looked at because of time constraints. If all the letters and numbers match the distance is considered minimal and a score of 0 is awarded. If a patent claim falls into multiple IPC classes and as such has multiple IPC codes, the scores are averaged using a weighted average based on the number of codes and the number of unique relations between them. The resulting scores are normalised to 1 and quantitatively analysed.

Hypothesis 3 is researched by taking the information under the header 'inventor'. The patents are divided into those made by a single inventor, and those made by multiple inventors. They are then also descriptively and quantitatively analysed by MCP and FUP to see whether or not support can be found. If no inventor is listed that is marked as a missing value.

To investigate hypothesis 4 information about the location where the patents were applied for is collected from the data under the headers 'inventor' and 'applicant'. This information is then split into the three categories of LME, CME, and Other. If a patent lists multiple inventors coming from both LME and CME countries, there is no way to determine the main institutional context and as such they are marked as missing values.

To statistically test for significance, the distributions found for follow-up patents are analysed using a Chi-Square goodness-of-fit test. This test is used because the variables are categorical, and each level of the categorical variables has an expected frequency count of at least 5. This cannot be done for the most-cited patents because the sample size is too small.

3.4 Validity

This is a form of systematic sampling. In this study this form of sampling is justifiable because we are trying to describe aspects of patents that could be indicative of being selected by institutions. This means the external validity is low, but the purpose of this study is not to provide generalisable statements. The purpose is to assess the internal validity of Hall & Soskice's (2001) claims using radical patents.

4. Results

In this section the results from the analyses are presented and interpreted in accordance with the theories used.

4.1 Results hypothesis 1

Both hypotheses have been analysed descriptively. The follow-up patents have also been analysed statistically using a Chi-Square test to lend strength to the results. This could not be done for the most-cited patents because there was insufficient data to do so. Of the ten most-cited patents (MCP) selected, one did not meet the criteria because it came from before 2010. It was therefore left out of the analysis. Out of the nine patents researched 66.7% came from LMEs. The rest (33.3%) came from the category Other. No patents came from CMEs. Out of the 248 follow-up patents (FUP) studied 62.1% originated in LMEs. The majority of follow-up patents came from LME countries.

Location	**MCP**		**FUP**	
	N	Percent	N	Percent
LME	6	66.7%	154	62.1%
CME	0	0%	16	6.5%
Other	3	33.3%	78	31.5%
Total	9	100%	248	100%

Table 2. Location of most-cited and follow-up patents. Distribution of follow-up patents is significant at $p < 0.01$.

These results lend support to VoC theory's claim that high-tech innovations are more strongly concentrated in LMEs than CMEs. Remarkable is that the distributions for both the most-cited and the follow-up patents are very similar. Roughly 60% in LMEs, 30% in Other countries, and the remainder in CMEs.

4.2 Results hypothesis 2

One most-cited patent did not cite any previous patents. Because of this, it was not scored and treated as a missing value. Just as with hypothesis 1, the data was analysed descriptively and the follow-up patents were also statistically analysed using a Chi-Square test. Only two most-cited patents scored high enough to be deemed radical. That amounts to 25% of the most-cited patents studied. For the follow-up patents the percentage is nearly identical with 26% of patents studied.

Score	**MCP**		**FUP**	
	N	Percent	N	Percent
Incremental	4	50%	102	38.5%
Undetermined	2	25%	94	35.5%
Radical	2	25%	69	26%
Total	8	100%	269	100%

Table 3. Scores for most-cited and follow-up patents. Distribution of follow-up patents is significant at $p < 0.05$.

These result do not support the VoC theory's claim that innovations in high-tech industries are more often radical than incremental. On the contrary even, for both the most-cited patents and the follow-up patents there are many more that score 'incremental'.

4.3 Results hypothesis 3

Of the patents studied 78% were made by teams consisting of multiple inventors. The majority of these, 128 out of 200, or 64%, came from LMEs.

Multiple inventors	**LME**		**CME**		**Other**		**Total**	
	N	Percent	N	Percent	N	Percent	N	Percent
Yes	128	80%	11	68.8%	61	76.3%	200	77.8%
No	32	20%	5	31.2%	20	24.7%	57	22.2%
Total	160	100%	16	100%	81	100%	257	100%

Table 4. Multiple inventors for all patents. Distribution patents is significant at $p < 0.05$.

Singh & Fleming (2010) argue that most radical innovations are made by teams. Since most patents (80%, 69%, 76%) in the high-tech OACM industry have multiple inventors, and by extension are more likely to be radical, and most of these patents (64%) originated in LMEs, this indirectly supports VoC theory's claim that LMEs innovate more radically.

4.4 Results hypothesis 4

In 92.6% percent of the cases the country of residence of the inventor was the same as the country of residence of the applicant.

Location	**Inventor**		**Applicant**	
	N	Percent	N	Percent
LME	160	62.3%	159	61.9%
CME	16	6.2%	18	7%
Other	81	31.5%	80	31.1%
Total	257	100%	257	100%

Table 5. Country of residence of Inventor and Applicant for all patents.

Identical	**N**	**Percent**
Yes	238	92.6%
No	19	7.4%
Total	257	100%

Table 6. Cases where country of residence of Inventor and Applicant are identical. Distribution is significant at $p < 0.01$.

Such a large number of cases where the countries of inventor and applicant are identical indicates that no issues have been found with the use of Inventor as opposed to Applicant for determining the location and institutional context of patents. This means that the choice of analysis method was correct.

The findings can be summarised in this table.

Hypotheses	**Obtained results**
H1.1: The top ten most-cited patent applications originating in the high-tech OACM sector are geographically concentrated in LMEs.	Yes, evidence has been found in support of this hypothesis.
H1.2: The first 50 follow-up patent applications originating in the high-tech OACM sector are geographically concentrated in LMEs.	Yes, evidence has been found in support of this hypothesis.
H2.1: The most-cited patent claims applied for in the high-tech OACM sector score >0.6	No, the results do not support this hypothesis.
H2.2: The follow-up patent claims applied for in the high-tech OACM sector score >0.6	No, results do not support this hypothesis.
H3: Patent applications made in the high-tech OACM sector are mostly made by multiple inventors.	Yes, evidence has been found in support of this hypothesis.
H4: The country of residence of the inventor is identical to the country of residence of the applicant.	Yes, evidence has been found in support of this hypothesis.

Table 7. Summary of findings.

5. Discussion

This study provided a novel way of testing Varieties of Capitalism theory's claims. It showed some interesting results that can be used in further research and also raises a number of questions that need to be answered in order to give a more complete answer. There are also certain points of improvement that future studies can take into account to acquire better results.

5.1 Limitations and suggestions for future research

First off, the results found in this study cannot be generalised beyond the scope of the patents studied because of the sampling methods used. Radical patents were needed for this study and because the radicalness could not be determined before the analysis, the choice was made to analyse the ten most-cited patents on the assumption that they were radical as the literature suggested. Due to the exploratory nature of the analysis method used, only a small number of often-cited patents was used. Now that the method has proven to yield results, more inclusive studies can be done with larger datasets to further test Hall & Soskice's claims and get more accurate results.

A second limitation is that the analysis could have been made more rigorous by adding the final digits of the IPC codes to the calculations for the technological distance. Doing so would have added another level of detail to the results. Unfortunately, that was not possible due to time constraints. However, the extra detail may also add extra noise to the data. All patents have some technological distance between them. If not, the patent would not have been granted as it would not have anything unique to offer. By remaining on the group-level, and not examining the sub-group level, this baseline uniqueness was taken out of the analysis, thereby reducing the inherent noise.

Another thing is that the LME/CME/Other categorisation used in this study does not rely on the most recent findings, but instead uses Hall & Soskice's original work. Because the category 'Other' is rather large, a certain amount of noise is introduced into the results. Future research should be done that utilises updated categorisations to reduce the noise.

Also, the cut-off points for radicalness were arbitrarily chosen. This was done in order to judge the data, but it lacks theoretical grounding. More research needs to be done to estimate more accurate cut-off points. To examine this issue in further detail, future research could use this method to analyse innovations that are classically said to be radical, like the qwerty-keyboard or the television (Christensen, 1997). They could be used to set benchmarks for the cut-off points.

Lastly, the method of analysis could have been flawed. However much attention was paid to ensuring consistent sampling and internal validity, it remains an experimental approach. Perhaps technological distance is by itself not a good measure for radicalness. To study this further, future research could replicate this study whilst controlling for other radicalness indicators like Trajtenberg et al.'s (1997) originality index or economic impact (Schneider & Paunescu, 2012). Another issue that needs to be worked out is how the initial patents are selected. It could be that the initial patents weren't 'radical enough' for this method to provide accurate results.

5.2 Theoretical implications

This leads to an interesting discussion point. Exactly how different do inventions need to be from each other to be regarded as 'radically different'? The most-cited patents, those that by the conventional approach of citation count would be regarded as radical, actually scored *lower* than their follow-up patents on technological distance. With respect their predecessors, the most-cited patents were more technologically similar than their follow-ups.

Since other studies by Meelen (2013) and Akkermans (2009) have found that LMEs do produce more radical innovations, this casts doubts on the use of citation count as an indicator for radicalness. This method, though widely accepted, is not uncontested (Jaffe & Trajtenberg, 2005). So long as the concept of radicalness is not properly defined and operationalised, studies using or studying it will have a hard time drawing conclusions.

Another discussion point is concerned with the categorisation of countries. A large number of patent claims originated from Asian countries such as China, Taiwan, and Korea. Under the grouping used, these countries all fall in the category Other. In opposition to this, Witt & Redding (2012) argue that China is a one-of-a-kind country that deserves its own category because it doesn't fit within the standard LME/CME paradigm. Tylecote & Visintin (2007) argue that Korea should also be in a separate group, one with France that they call Government coordinated market economies. Of Taiwan they say that while it is a CME, it is not one with stakeholder capitalism like Germany or the Netherlands. Rather, it has family/state capitalism like the South European countries and therefore it should be in a distinct group as well.

There still is much debate over which countries should go into what groups. In order to test Varieties of Capitalism theory's claims more accurately and to verify this study's findings, more research is needed on the sustainability of the LME/CME categorisation as it is now. Because of VoC theory's focus on firms, it fails to take into account the role of the state in countries' economies. Which in turn means that the criteria for the categorisation into LME or CME, or perhaps another sort of economy that falls in between them, also gloss over this important aspect of capitalistic countries.

All in all, VoC theory rests on two major pillars; the definition of 'radicalness' and the categorisation of countries. To the detriment of the theory, both of these pillars are contested. More research is needed in order to resolve the issues present and to give the theory a more solid knowledge base on which to build further.

6. Conclusions

In this study the question was asked to what extent LMEs are more favourable than CMEs for high-tech, radical innovation development in the Office, Accounting and Computing Machinery sector thanks to their respective institutional contexts. This was done by selecting the ten most-cited patents and their 50 first follow-up patents in the OACM sector and analysing them on origin and radicalness. This study finds that LMEs are more heavily represented in the high-tech OACM sector than CMEs. Using technological distance as an indicator for radicalness the patents were not found to be radical, the majority was found to be incremental, even for the most-cited patents. Using ‘having multiple inventors’ as an indirect indicator for radicalness, a majority was found to be radical. These results support VoC theory’s claim of industry specialisation by LMEs. They do not, however, fully support the claim of radical innovation specialisation by LMEs.

This study concludes that similar to what Meelen (2013) found, LMEs are favoured by their institutional contexts for high-tech industry specialisation, but not for radical innovation. This result can be explained by drawing the operationalisation of radicalness into question. Both citation count and technological distance were used for this, but neither provided radical patents. More accurately defining and operationalising radicalness seems to be a crucial piece in resolving the VoC paradox.

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8. Appendix

The following is a table with all patents used in the analyses. The most-cited patents are in bold. The patents after that are the follow-up patents corresponding to that most-cited patent.

Patent	Type of economy (by inventor)	Normalised score of technological distance	Citation count (most-cited patents)
US20100691318	**OTHER**	**0,37**	**32**
US201113267040	LME	0,13	
US201113200773	LME	0,00	
US201113244885	LME	0,00	
US201213597473	LME	0,00	
US201213436932	LME	0,13	
US201213584812	CME	0,00	
US201113311390	LME	0,25	
US201113077440	LME	1,00	
US20100652721	**LME**	**0,75**	**52**
WO2011US65915	LME	0,67	
US201213632130	LME	0,75	
JP20110181618	--	0,83	
DE20111010919	CME	0,50	
US20100769654	OTHER	0,50	
GB20130020620	--	0,50	
US201214111380	LME	0,50	
WO2012KR11790	OTHER	0,50	
US201213491149	LME	0,38	
KR20110034843	--	0,38	
US201213584831	OTHER	0,50	
US20100689834	LME	0,50	
US20110930590	CME	0,50	
US201113021455	CME	0,50	
US201113336425	LME	0,50	
WO2012US21448	LME	0,50	
WO2012US21442	LME	0,50	
US201213438646	OTHER	0,50	
US201213485107	LME	0,50	
US20100980543	CME	0,50	
EP20110006079	OTHER	0,75	
US20110930610	CME	0,63	
US201213532885	--	0,83	
TW20120127715	OTHER	0,25	
WO2012US21446	LME	0,50	

US201113174448	LME	0,50	
US201113188852	--	0,50	
US201213463241	LME	0,50	
US201213538055	--	0,50	
KR20120061446	--	0,50	
CN2011187532	OTHER	0,75	
US201314054570	LME	0,50	
US201313899536	--	0,50	
US201313948117	--	0,50	
US20100705652	LME	0,75	
US201113182305	LME	0,00	
WO2012IB50935	LME	0,00	
JP20130556624	LME	0,00	
EP20120161120	LME	0,00	
US201113092876	OTHER	0,50	
US201113085195	LME	0,00	
US20100940383	LME	0,63	
US20100767814	LME	0,75	
US201213593993	OTHER	1,00	
US201113052885	OTHER	1,00	
US20100652725	**LME**	**0,13**	**49**
EP20120827966	LME	0,83	
CN20111436269	LME	1,00	
WO2013IL00039	--	0,45	
TW20130114773	CME	0,83	
JP20100066494	--	0,56	
NL20111039215	--	0,32	
US201113333558	OTHER	0,75	
WO2012GB52876	LME	0,44	
US201113306355	OTHER	0,39	
WO2012SE51072	CME	0,58	
EP20110178860	OTHER	0,47	
WO2013KR02570	OTHER	0,00	
US201213677902	--	0,50	
WO2010JP01804	CME	0,75	
WO2013SE50121	CME	0,33	
US201113233433	LME	0,33	
US201113233376	LME	0,56	
US201213684093	LME	0,67	
JP20130535001	LME	0,67	

US20100869179	OTHER	0,78	
US201213548834	LME	0,75	
US20100874840	CME	0,78	
EP20120187992	LME	0,75	
WO2011US40969	LME	0,71	
WO2012US20499	LME	0,33	
WO2011KR00602	OTHER	0,67	
KR20110011071	OTHER	0,78	
WO2013US56276	LME	0,47	
US201213343981	OTHER	0,33	
US20100898870	OTHER	0,33	
US201313844756	LME	0,33	
US201213431638	LME	0,17	
US20100917265	LME	0,17	
US20100938029	LME	0,17	
US201113038219	OTHER	0,17	
US201213487513	LME	0,17	
WO2013FI50009	CME	0,17	
US201213566573	LME	0,17	
US20100817969	LME	0,17	
US201113291918	LME	0,17	
US201113022558	OTHER	0,00	
KR20120021240	OTHER	0,83	
TW20120114427	OTHER	0,81	
EP20120157234	LME	0,75	
US201313940069	LME	0,38	
US201313947943	LME	0,83	
US20100651956	**LME**	**0,33**	**32**
US201113296022	LME	0,13	
US201213415430	LME	0,13	
US201213525182	LME	0,13	
US201213597001	LME	0,13	
US201113174453	LME	0,13	
US201113316741	LME	0,13	
US201213705407	LME	0,40	
US201113340974	--	0,42	
US201113327279	OTHER	0,58	
JP20110009727	LME	0,50	
US201113174537	LME	0,50	
US201113180495	LME	0,50	

US201113300078	LME	0,50	
US201113302119	LME	0,50	
US201213369468	LME	0,50	
US201213362409	LME	0,50	
US201213412520	LME	0,50	
US201213426714	LME	0,67	
US201213539709	LME	0,50	
US201113227416	LME	0,50	
US201213474660	LME	0,50	
JP20120054025	LME	0,50	
TW20130104392	LME	0,25	
US201313741003	LME	0,75	
US201213525188	LME	0,92	
US201213372580	LME	0,88	
US201213652182	LME	0,75	
US201213681917	LME	0,75	
US201213545784	LME	1,00	
US201213603104	LME	1,00	
US201213533207	LME	1,00	
JP20130009873	LME	1,00	
US20100693510	**OTHER**	**0,20**	**35**
EP20130003243	LME	0,00	
US20100751915	LME	0,13	
US20100960489	LME	0,13	
WO2012US43298	LME	0,25	
US201213425608	OTHER	0,50	
US201113022299	LME	0,50	
WO2013US54399	LME	0,50	
CN2011801170	OTHER	1,00	
US201213663403	OTHER	1,00	
US20100657792	**LME**	**0,56**	**33**
US201213630518	LME	1,00	
US201213422419	OTHER	0,50	
KR20110069124	OTHER	0,25	
KR20110083168	OTHER	0,25	
WO2012KR08911	OTHER	0,33	
JP20130533897	LME	0,25	
US201113043268	LME	0,35	
US201113043270	LME	0,35	

US201113043203	LME	0,50	
US20110985982	LME	0,50	
CN20121167333	OTHER	0,00	
US201313826171	LME	0,00	
US201313829741	LME	0,00	
US201313829908	LME	0,25	
US201313829829	LME	0,25	
US201113010976	LME	0,25	
WO2012US64760	LME	0,38	
US201313829209	LME	0,50	
US201313829056	LME	0,50	
US201313829641	LME	0,50	
US201313829978	LME	0,50	
US201314021246	LME	0,50	
US201113088053	LME	0,50	
US201113088038	LME	0,50	
US201113088032	LME	0,50	
US201113088048	LME	0,50	
HK20110113382	--	1,00	
WO2013CN79313	OTHER	1,00	
US20100871822	LME	1,00	
WO2013EP62586	OTHER	1,00	
US201313920005	**LME**	**0,69**	**31**
CN20131114537	LME	0,80	
US20100761922	OTHER	0,35	
US201113152341	LME	0,35	
US20100982830	OTHER	0,00	
CA20112794781	LME	0,00	
US201113134064	LME	1,20	
US20100694368	LME	0,00	
US201113272619	LME	0,35	
US201113341026	LME	0,35	
US201213435098	LME	0,35	
US201213490836	LME	0,35	
US20100895505	LME	0,00	
EP20110150927	LME	0,57	
WO2012IB50229	LME	0,35	
US201213493642	OTHER	0,35	
US201313875109	LME	1,21	
KR20100106759	OTHER	1,80	

US201113023907	LME	0,40	
US201113214489	LME	0,35	
US20100827713	CME	0,35	
US201314043902	LME	0,85	
US201314096418	LME	0,85	
WO2013US63429	LME	0,85	
US201313830016	LME	0,85	
US201414188758	LME	0,80	
CN20101132589	**OTHER**	**--**	**38**
CN20111382274	OTHER	0,75	
CN2012165316	OTHER	0,46	
WO2012CN76455	OTHER	0,32	
CN20111366530	OTHER	0,58	
CN20111366625	OTHER	0,58	
WO2011CN82809	OTHER	0,58	
CN20111366431	OTHER	0,58	
WO2011CN82811	OTHER	0,42	
WO2011CN82815	OTHER	0,42	
CN20111366622	OTHER	0,42	
CN20111366119	OTHER	0,42	
WO2011CN82808	OTHER	0,42	
CN20111366478	OTHER	0,42	
CN20111371617	OTHER	0,42	
CN20111308489	OTHER	0,47	
US201113381904	OTHER	0,47	
WO2011CN82638	OTHER	0,47	
US201113381899	OTHER	0,47	
WO2011CN82653	OTHER	0,47	
WO2011CN82790	OTHER	0,47	
WO2011CN82688	OTHER	0,60	
CN20111366320	OTHER	0,39	
CN2012165380	OTHER	0,39	
CN20111396003	OTHER	0,46	
CN2012126567	OTHER	0,46	
CN20111352045	OTHER	0,46	
US201113381325	OTHER	0,33	
WO2011CN82904	OTHER	0,25	
WO2011CN82806	OTHER	0,92	
WO2011CN82676	OTHER	0,92	
CN20111366187	OTHER	0,92	

WO2011CN82812	OTHER	0,92	
CN20111367106	OTHER	0,92	
US201113381905	OTHER	0,92	
DE201111105337T	OTHER	0,67	
WO2011CN82889	OTHER	0,50	
US201113381903	OTHER	0,64	
US201113381901	OTHER	0,50	
US20100858718	**LME**	**0,50**	**32**
US201213590352	LME	1,00	
JP20120001005	--	0,50	
DE20121020169	CME	0,75	
US201113271433	LME	0,25	
US201113085839	LME	0,25	
US20100951160	LME	0,25	
US201113229241	LME	0,25	
US201414173829	LME	0,25	
WO2013US30813	LME	0,25	
WO2012US42044	LME	0,00	
AU20120295528	LME	0,00	
AU20110292291	LME	0,00	
US201314096135	LME	0,00	
NO20110001345	CME	0,00	
US201113157214	LME	0,00	
US201213544956	LME	0,00	
TW20120103068	OTHER	0,00	
US20050180035	LME	0,25	
US201213631307	LME	0,25	
JP20100210912	--	0,25	
US201113239349	LME	0,25	
US201213621793	LME	0,50	
US20070925702	LME	0,50	
US201213402853	LME	0,50	
US201213652443	LME	0,50	
US201213408168	LME	0,50	
US201213436817	LME	0,50	
WO2011US58650	LME	0,50	
WO2013CN77461	OTHER	0,75	
US201113211182	LME	0,75	
CN20131680304	CME	1,00	
US201213444512	LME	1,00	

Table 8. List of all patents analysed with corresponding normalised scores.