

Impacts of Networks on the Emergence of Dominant Design – Float Glass in Canada

Work-in Progress Paper
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ABSTRACT

The paper focuses on the emergent of dominant design in national market where the radical technological change dramatically replaced the resources in the network. Especially, the focus is on the group of stakeholders affecting the domestic content of product manufacturer by foreign multinational companies. We contribute to the literature of technology management which does not see the context of simple nonassembled products and their manufacturing technology. Here we interpret the social, political and organisational influence with the help of the network (IMP) literature.

We apply the case study method that is considered as the most suitable method for the business network. Our case study may be described as longitudinal, historical and contextual. The data has been originally collected for a dissertation (Uusitalo, 1995) and further publications (e.g. Uusitalo, 1997).

We found several connected technological, economical and political events that triggered the changes within the industry and had significant impacts on the Canadian flat glass industry. Based on the consequences reported in this study, we suggest that in complex business networks actors need to see things from several perspectives.

Keywords: innovation, dominant design, networks, stakeholders

1. Introduction

In the IMP literature cross border relationships and networks are key factors explaining firm internationalisation and the development of foreign markets. There is growing recognition that relationships with political actors (not only inter-firm relationships) such as governments can also be critical to foreign market activities (Welch and Wilkinson, 2004) and thus, also to the diffusion of innovations. Welch and Wilkinson (2004) focused the steadily accumulating research of political embeddedness of business networks. Their as well as this study contribute to our understanding of inter-firm relationships and business networks by showing that “delimitation of political actors from business transactions leads to conclusions far from the real business world” (Hadjikhani and Sharma, 1999:256)

This paper examines the factors influencing the emergence of dominant design within an industry. We look at simple, nonassembled products such as flat glass. Here we combine literature of technology management (Anderson and Tushman, 1990, Tushman and Rosenkopf, 1992, Turhman and Murman, 1998 and Murmann and Frenken, 2006), literature of networks (Easton, 1992, Håkansson, 1989 and Johanson and Mattsson, 1988, Welch and Wilkinson, 2004) and literature of stakeholders (Rowley and Moldoveanu, 2003 and Mitchell and Agle, 1997). According to Tushman and Rosenkopf (1992) and Tushman and Murman (1988) there is little interorganisational influence on the emergence of dominant design for nonassembled products.

However, a longitudinal case study of two non-assembled products, sheet glass (1920-1984) and plate glass (1900-1984) and one radical innovation, float glass in both the North American (NA) sheet glass and plate glass industries, indicates that there are interorganizational effects in the diffusion of nonassembled products. We illustrated generally the NA market and take a closer look at the Canadian market. The float glass process was taken in Canada after the involvement of several stakeholders such as the Canadian Government, US car manufacturers and Pilkington. As was said Tushman and Rosenkopf (1992) found little social/political/organisational influence on the emergence of a dominant design for non-assembled products. One reason may be the fact that innovation in original Anderson and Tushman’s (1990) model, which Tushman and Rosenkopf’s (1992) typology is based on, was defined as the first commercial introduction flat glass produced in the US. Thus, the international impact on the diffusion of innovation was neglected.

As late as 1970 the flat glass industry had two separate industries, sheet glass (also known as window glass) and plate glass (see Figure 1). The float glass innovation has its origins from both industries. It aimed to have optical quality from the plate glass industry and “fire-finished” manufacturing method from the sheet glass industry.

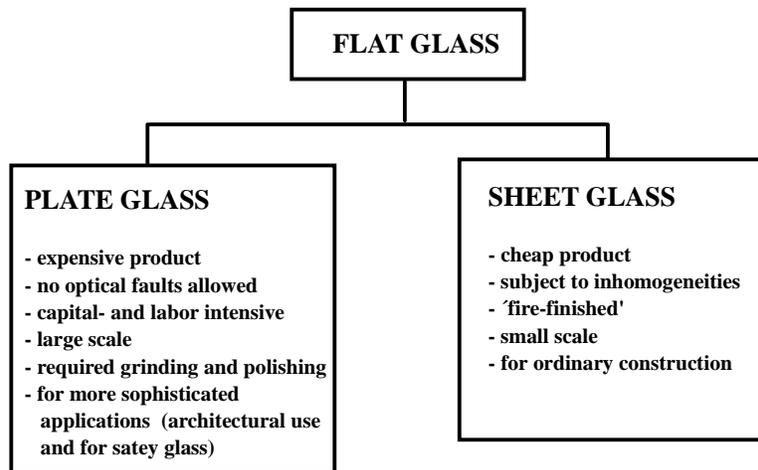


Figure 1. The Division of Flat Glass in the 1950s

The R&D process of float glass in Pilkington, that time a UK based family owned company, took seven years. During the R&D process the company made a strategic decision to position float glass as a readymade product in the plate glass industry and not too quickly in between two industries. In the 1960s Pilkington developed the float glass technology so that it was able to compete with the float glass technology also in the sheet glass industry (see Figure 2.).

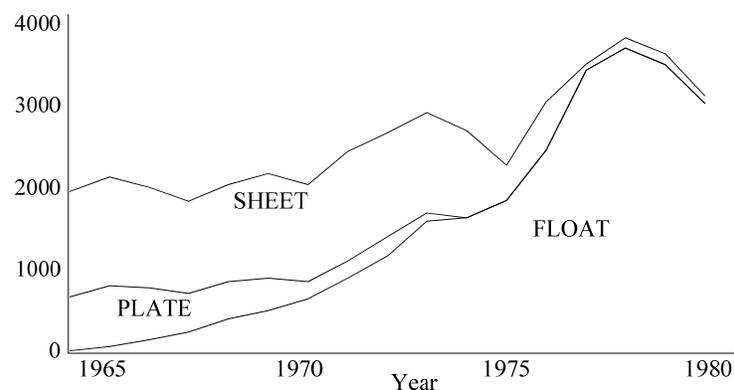


Figure 2. Flat Glass Production in the U.S., 1964-1980 (Millions of Sq. Ft.) (Edge, 1984).

The remaining part of the paper is organized in the following way. First, we introduce theoretical foundations of our study, including the literature of technology management, networks and stakeholders. Second, we describe the methodology of the study. The methodology is based on a longitudinal, historical and contextual case description applying multiple sources of data. Third, we report our empirical case the diffusion of float glass manufacturing in the Canadian flat glass industry with the help of the Canadian automotive industry. Finally, we draw conclusions and discuss implications and further research.

2. Literature

Technical progress in an industry usually consists of long periods of incremental change (Figure 3). A technological discontinuity inaugurates an era of ferment in which competition among variations of the original breakthrough ends with the selection of a single dominant design of the new technology. The era of ferment has two processes: the design competition and the technological substitution. The incremental evolution of this standard design goes on until a new discontinuous technological change will come. (Anderson and Tushman, 1990) Technological discontinuities are not all alike. Tushman and Anderson (1986) characterized technological discontinuities as competence-enhancing or competence-destroying. On the one hand, competence-enhancing discontinuities significantly advance the state of the art yet build on, or permit the transfer of, existing know-how and knowledge. Competence-destroying discontinuities, on the other hand, significantly advance the technological frontier, but with a knowledge, skill and competence base that is inconsistent with prior know-how.

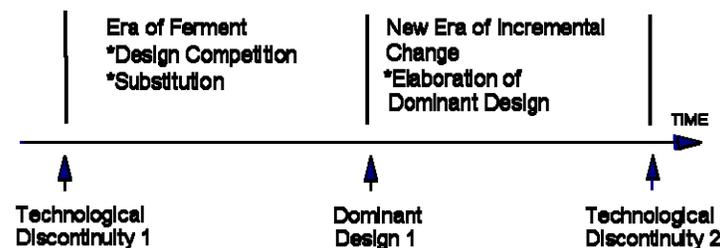


Figure 3: The cyclical model of technological change

Technology is as systems composed of component and linking technologies. The more complex the product is, the more subsystems exist, the greater the number of internal and external interfaces becomes and the greater the technical and contextual uncertainty is. Thus, while the technical system itself may suggest logical evolutionary paths, as the system gains complexity, nontechnical forces weigh more heavily on the process of technological evolution (Figure 4). The greater these uncertainties are, the greater the intrusion of socio-political dynamics in the evolution of a particular technology becomes. (Tushman and Rosenkopf, 1992). According to authors (see Figure 2 also) there is little social/political/organisational influence on the emergence of a dominant design for non-assembled products such as cement and flat glass.

The political embeddedness of a business network may have four forms: 1) political institutions, 2) political actors, 3) the political activities of firms and 4) political resources (Johanson and Mattsson, 1991). States and other political institutions provide evolving networks “a framework of rules and regulations within which private actors have to play” (Salmi, 1995:68). Research on political institutions has focused on the effects of “political turbulence” as a discontinuous change in political ideologies such as the fell of iron curtain (Hadjikhani and Johanson, 1996) or incremental change such as the European integration. Political actors include bureaucrats, government ministers, members of parliament, opposition parties, interest groups and the media (e.g. Hadjikhani and Håkansson, 1996). They can help change the business network through constructive or disruptive moves. Infrastructural networks having often political actors are not

directly buying or selling, but acting as vehicles for information, communication and influence they “may be as important as the business relationships” (Hallén, 1992:79).

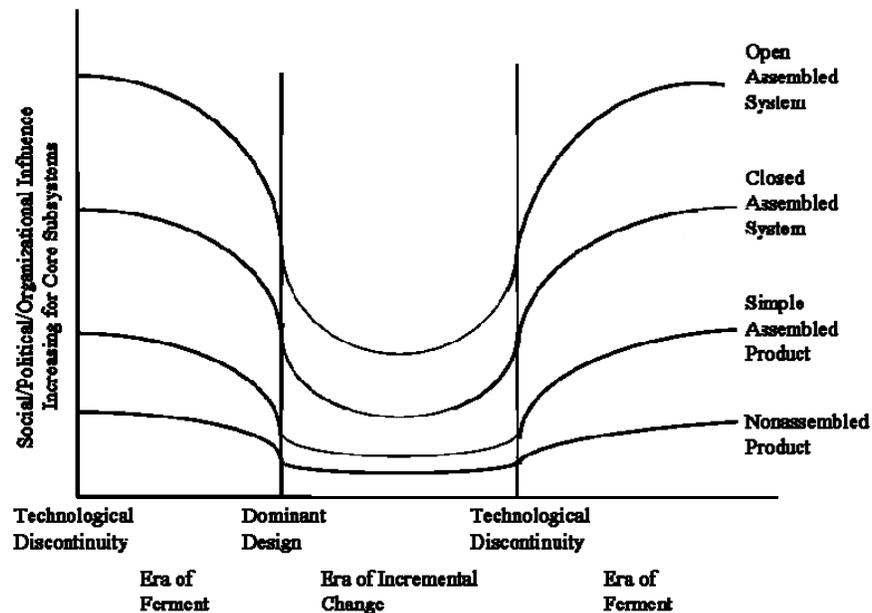


Figure 4: Toward Sociology of Technology

Political activities include the actions and interactions of political actors and firms as they intersect with business, as well as the political activities of firms. The latter focuses on the way businesses lobby governments and influencers of public opinion. Firms are “involved with the political system” (Halinen and Törnroos, 1998:196). For firms the government’s have several political resources: 1) public sector contracts 2) licences and approvals, 3) industry policies and regulation, 4) support in the form of tax concessions, tariffs and other protectionist measures, 5) funding for research and development and regional development (Hadjikhani and Sharma, 1996). To get legitimacy and influence, firms must invest in political relationships (Hadjikhani, 2000).

According to Rowley and Moldoveanu (2003) it is important to know what stakeholders a firm has, what is the demand or goal of each of the stakeholders, how each stakeholder intends to meet their goal, what influence strategies they have. Moreover, the firm should know how to relate itself to each of the stakeholders and how to prioritize their (many times conflicting) goals? According to Rowley (1997) stakeholder relationships do not occur in a vacuum of dyadic ties, but rather in a network influences. Thus, a company’s stakeholders most probably have direct relationships with one another. Freeman and Evan (1990) say that the stakeholder environment consists of “a series of multilateral contracts among stakeholders” (1990:24).

In order to analyse the social/political/organisational influence on the emergence of a dominant design for non-assembled products we use the political embedded networks as a tool. Our framework

consist of the toward sociology of technology (Tushman and Rosenkopf, 1992) and the political embedded networks (see Figure 5).

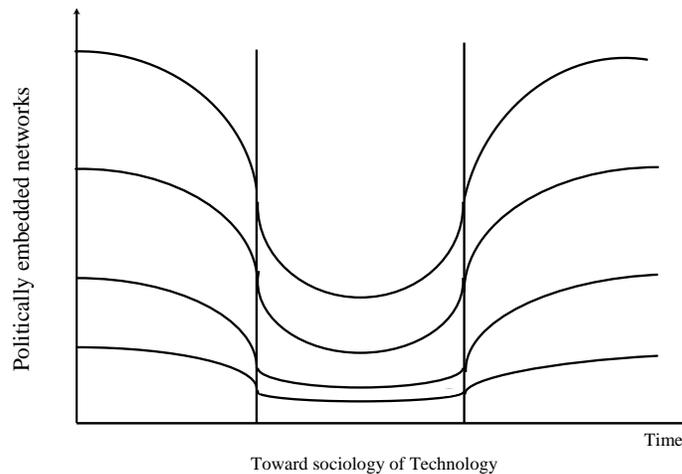


Figure 5: Research framework

3. Methodology

The present study adopted a longitudinal, historical and contextual case study approach. According to Yin (2009) a single case study is an appropriate design under when the case represents a critical case in testing a well-formulated theory, proposition or model (in this case toward sociology of technology, Tushman and Rosenkopf, 1992). Pettigrew (1985) argues that to understand a change one has to study it as a continuing process in the context in which it appears, and he encourages one to adopt a contextual and historical perspectives on processes of change, whatever the content of the change might be. The aim in this research is to choose "a video camera view instead of a snap shot" as Pettigrew and Whipp's (1991) put it.

A single case study design has certain advantages compared with multiple cases. The most important is the depth of the analysis, both in terms of the number of factors studied and sources of information used (Yin, 2009). A single case analysis is the best way to get a holistic picture and understanding of the research problem. Patton (1990, p. 95) has argued that "qualitative inquiry is highly appropriate in studying processes because depicting a process requires detailed description". Since the unit of analysis in the present study was the float glass innovation in the Canadian flat glass industry, the final design of this study was an "embedded, multiple case study design" (Yin, 2009). Two cases permits a "replication" logic (Yin, 2009) in which cases are treated as a series of independent experiments that confirm or disconfirm emerging conceptual insights.

Porter (1980) points out that in an industry analysis there are important benefits in getting an overview of the industry first, and only then focusing on the specifics. According to him, experience has shown that a broad understanding can help the researcher to spot important items of data when studying sources and organize data more effectively as they are collected. Porter (1981) also stresses the value of in-depth industry histories in understanding industry environments and identifying firms' strategic interactions on a longitudinal basis.

Since the purpose of this paper is to re-examine theory, the number of industries and technological changes enhances the depth and quality of data collected, as recommended by Berg and Smith (1988) and Eisenhardt (1989). The float glass innovation and one industry, the Canadian flat glass, were selected because:

- 1) float glass was radical and complex enough to test Tushman and Rosenkopf's (1992) typology,
- 2) the discrepancy in diffusions created uncertainty whether float glass technology will replace also the existing sheet glass technology
- 3) the studied industries in the U.S. and Canada are well documented

The research periods for the sheet glass and plate glass industries are 1920-1984 and 1920 - 1984, respectively. The technological change, float glass, was introduced in 1959, respectively, and thus the research period was long enough to analyze the diffusion of these innovations.

To improve the validity of our "analysis" we used the triangulation methods described by Jick (1979) and Pettigrew (1990) to construct case studies from a variety of information sources: personal interviews in 1993-1996 (business managers in Pilkington, the author of Pilkinton's histories), company and industry histories (Barker, 1977 and 1994; Hamon, 1988), industry and technology studies or books (Grundy, 1990; Doyle, 1979; Pincus, 1983; Tooley, 1984), business periodicals (Salmans, 1980; Wierzynski, 1968), books written by businessmen, company correspondence, academic studies (Frederiksen, 1974; Skedde, 1977) and journals, news clippings from the mass media, statistics and trade journals (The Glass Industry and Ceramic Industry Magazine; all from the area 1950-1984). The information given in these magazines has been compared and the critical events have been checked and verified in at least two of them. The data analysis is crucial in the case of causal studies. Internal validity deals with establishing a causal relationship, whereby certain conditions are shown to lead to other conditions. The internal validity can be increased by using pattern recognition (Mintzberg, 1979) or seeing evidence through multiple lenses (Eisenhardt, 1989). Table 1 provides the different perspectives.

Table 1. Viewing the Research Phenomenon from Different Perspectives

Perspective	Focus of analysis
Technology	Plate, sheet and float glass manufacturing processes
Technology transfer	Wholly-owned subsidiary, licensing
Industry	The plate glass and sheet glass industries
Economy, large	The U.S.
small	Canada
Global	Licensing of float glass
Company, large (MNC)	Pilkington, St. Gobain, PPG
small	Sheet glass manufacturers
Vertical integration	The safety glass industry, the car industry

4. Pilkington, float glass and Canada (and the Canadian car industry)

This section provides an illustration of the evolution of the flat glass industry in Canada in the US and the car industry in Canada. The section contains four sub-sections. In the first section, to understand the flat glass industry before the float glass innovation, the subindustries of sheet glass and plate glass

as well as the evolution of the flat glass industry in general in 1950-1960 are briefly described. In the second section the float glass innovation is introduced. In the third section the effects of the emergence of float glass on the flat glass industry are analyzed. In the fourth section we discuss also the Canadian car industry in the 1960's.

4.1 Flat Glass Manufacturing in 1950-1960

Continuous sheet glass production methods were invented in the early 1900s (Doyle, 1979). Sheet glass was drawn into a ribbon through a block floating on the surface of the molten glass. The ribbon passed vertically upward through an asbestos roller and then into a cutting room where the cooled, hardened glass was cut and stacked. Sheet glass was cheap glass subject to inhomogeneities and optical distortion. It was suitable for ordinary windows used in construction. In the 1950s all manufacturers used continuous processes. To make plate, molten glass was rolled into a plate with a waffled surface and then ground and polished until both surfaces were smooth and parallel. Plate glass was needed in more sophisticated applications such as mirrors and the large windows used for retail displays and architectural effects, where the inhomogeneities and optical distortion were not acceptable. Large flat glass manufacturers produced both cheap sheet glass and expensive plate glass.

Since 1920s the expanding and internationalizing car industry was the main customer for the plate glass industry, because most safety glass was made from plate glass. To guarantee plate glass sales in the 1930s, Pilkington from the UK internalized the safety glass manufacturing in the UK, Canada, Australia and South Africa (Barker, 1977). Because of the strategic importance of the internationalizing (or globalizing) car industry, the plate glass industry also faced a great deal of pressure to globalize.

In 1935 Pilkington introduced a 'twin' grinding machine to grind both sides of a plate glass ribbon simultaneously, which lowered the cost of plate glass. The company licensed twin grinding technology selectively to the plate glass producers, PPG and LOF (Barker, 1977) for the US territory. In the 1950s with the high capital costs, which the introduction of continuous machinery entailed, entries into the plate industry because of high entry barriers (Porter, 1980) became both difficult and unattractive. World demand for plate glass could be satisfied by a handful of large producers located in the main industrial countries. By 1960 Pilkington, BSN, St. Gobain and Glaverbel produced plate glass in Europe while PPG, LOF and Ford in the U.S. The sheet glass and plate glass industries targeted different customers and were quite different. In 1951 Pilkington started sheet glass production in Canada. The Canadian market did not justify the investment in the plate glass plant.

4.2 The float glass innovation

In the float glass process a continuous ribbon of glass moves out of the melting furnace and floats along the surface of an enclosed bath of molten tin. Float glass is "fire finished" having no grinding and polishing phases. The quality of float glass is equal to that of plate, but the investment and production costs were much less than those of plate. At the beginning the only possible thickness was 6.5 mm, which just happened to match the most used thickness in the auto industry (as safety glass for side panes). Pilkington gradually introduced float glass into safety glass without anyone knowing the difference. Pilkington launched float glass in 1959 to replace the labor- and capital-intensive plate

glass process (Salmans, 1980). The new process was a total surprise to the industry. Furthermore, in the late 1960s a thinner float glass enabled float glass to enter also the sheet glass industry.

4.3 The NA Flat Glass Industry in the 1960s and the early 1970s

Eventually Pilkington licensed float technology strictly to only the plate glass manufacturers and only for their domestic territories (see Figure 2) (Barker, 1994). Thus, St. Gobain, a French plate glass manufacturer, was not able to license float glass technology for its US plate glass plant. The chairman of Pilkington described certain key aspects of the resulting strategy as follows:

"We had the great benefit of time to decide upon the strategy (the development of float glass took seven years). A great deal was said about ethics: that it was not our job to deliberately deny any existing glass competitor the opportunity of living in competition with us. I don't think we were shortsighted or rapacious... There was a great deal of investment worldwide in plate (glass), and people needed to have time to write off this plant or convert over. The alternative was chaotic disruption of a great industry."

In the early 1960s it was not evident that float glass would also replace sheet glass. In 1967 float glass was sold for glazing in applications where plate glass is normally used; in schools, offices, buildings, and increasingly in residential construction. Float glass was quickly in safety glass manufacturing all over the world for both laminated and tempered glass in automobiles - windshields, side lites, and back lites. Sheet glass producers, such as PPG opened new plants in 1967 and 1968 in the U.S. and Canada, respectively. By 1970 Pilkington could produce 2 mm thick float glass. Float glass competed with sheet glass in NA (Edge, 1984:714/4).

Float glass accelerated globalization of the industry. In 1968, tinting float glass was accepted quickly in the auto industry. Around 1970 the capacities, automatization and thus productivity increased considerably. Sheet glass was not challenged before float glass was cost-effective enough to replace the existing technology. The situation in the US (Figure 2) illustrates well, how float glass made these two subindustries obsolete one by one. In the 1960s when float glass diffused to NA, many interesting social and political events took place within the link between flat (i.e. float) glass and safety glass. In the late 1960s, Pilkington built two float glass lines in Canada to produce float glass for the safety glass manufacturers in Canada. Canada preferred local safety glass supplies for its growing auto industry.

4.4 The Canadian car industry in the 1960s

In the early 1960s four U.S. car manufacturers, GM, Ford, Chrysler and American Motors, operated in Canada. In 1963 to 1966, the car production in Canada rose from 633,000 units (Table 2) in 902,000 units, and employment, from 60,000 to almost 85,000. That time the Canadian exports of cars and original parts to the U.S. increased from \$40 million to \$845 million. Imports from the U.S., which were \$605 million in 1963, reached \$1501 million in 1966. Although trade diverted it was beneficial to both Canada and the United States.

Purpose of Agreement (the Canada-U.S. Automotive Products Agreement, Jan. 1965)

The purpose of the agreement was to make the U.S. car manufacturers (Table 2) continue their operations in Canada. The agreement stipulated that all tariffs on motor vehicles and original equipment parts (freighted from the U.S. to Canada, and vice versa, at the manufacturer's level) be abolished, if the Canadian subsidiaries do the following:

1. Maintain the same ratio of Canadian production to Canadian sales as in the 1954-model year.
2. Maintain a 60 per cent "Canadian content" in car production. That is, Canadian-built cars must contain at least 60 per cent Canadian parts.
3. Increase Canadian output by \$260 million by mid-1968.

Table 2. The Canadian car production (1960-1967).

Year	Passenger cars	Commercial vehicles	Total
1960	325,752	70,569	396,321
1961	327,897	62,834	390,731
1962	428,710	80,070	508,780
1963	533,783	99,134	632,917
1964	560,678	110,340	671,018
1965	710,278	144,453	854,731
1966	701,537	200,559	902,096

As was mentioned in the early 1960s, before float glass was operational, the Canadian Government had asked Pilkington to build a plate glass plant in that country, but it was found that the cost, compared with the probable demand, would not justify it. Thus, Canada continued to depend on imports as the sole source of plate glass for the domestic market. However, later on when float glass had become more efficient and the Canada-U.S. Automotive Products Agreement (Jan. 1965) was signed a float glass plant seemed to be feasible. Pilkington (Canada) pointed out that this 'Canadian' content in the agreement had a definite influence on the decision to begin the Canadian float project (TGI, September 1967:487-8).

To understand the events in Canada one has to have a wide picture of the international flat glass industry and the diffusion of float glass in NA market. The car industry via the need of safety glass was a very important user of plate glass. In the 1960s the car industry was one of the main industries in NA. Thus, government in both the U.S. and Canada took good care of it. The arbiters of dominant design for float glass in the NA market are illustrated in Appendix 1.

5. Discussion

As we saw from the NA illustration (Appendix 1) the flat glass, safety glass and the car industries had tight connection. Flat glass needed safety glass as marketing channel and safety glass needed flat glass as raw material while the growing car industry having more glass per car needed safety glass. The Canadian Government, as a political actor, had been involved already in the 1950's with the US car manufacturers production in Canada. The domestic content, the political resources Canada had, was a challenge. There were not enough good quality local producers. Pilkington's sheet glass was not accepted as the raw material for safety glass in the car industry. Pilkington did not see the Canadian car manufacturing justifying critical mass for a plate glass plant.

When the Canadian and US Governments, as political actors, negotiated the renewal of the Trade Pact in the mid 1960s Pilkington had experience in float glass manufacturing both from its own plants and its licensees' plants. Moreover the most important customer of processed float glass, the car industry, new also the potential (lower price, faster delivery times, tinting, low production change

setting times) of float glass. The relationship between Pilkington and the Canadian Government that time was very good. Pilkington was UK based company thus, the Commonwealth was one nominator. The second was the fact that the Canadian Government had already asked Pilkington for a plate glass plant. According to Pilkington (1969) Canada had set a code of good conduct – a code of guide lines – for those who come here. Moreover, Pilkington (1969) illustrated the code of the Pilkington company by saying:

“There are two schools of thought. One (the second) believes that business is only shortsighted and selfish, in the late 19th century image; this is widely believed by governments everywhere, but specially in developing countries. The other (the first) is that business is adult and farsighted, realizing that self interest should be enlightened, that co-operation and good conduct pay, that we are 29th and 21st century, not 19th. I believe the first school of thought, form long experience, but we in international business have to prove it to be true – and do so in face of growing nationalism.”

With this attitude and the ability to license the technology to its Canadian daughter company Pilkington had excellent possibilities to use its political activities.

Immediately after the Trade Pact was sign Pilkington licensed the technology to its Canadian subsidiary and started float glass production in 1967. In the late 1960s PPG developed its sheet glass technology. The company opened new sheet glass plants in the US and Canada in 1967 and 1968, respectively (Allen, 1967, 1968). PPG’s Canadian subsidiary with its high quality sheet glass targeted to the safety glass market and the Canadian car industry (providing the domestic content).

6. Conclusion

In window glass, Europeans licensed machine blowing from the US in the 1910s; since the 1920s European companies licensed drawn sheet glass processes from the US and vice versa. In plate glass, the US based PPG acquired its first plant in Europe already in 1904; in 1934 the US and European plate glass manufacturers formed an international cartel to share the world market (Barker, 1994); in the 1950s the US manufacturers licensed twin grinding technology from Pilkington. Ray (1969) noticed the unique international structure of the flat glass industry. How should one define innovation in such international industries as the flat glass?

The political embeddedness literature of an international business network takes neatly in the account the innovation introduced outside the research area. The float glass technology was developed in Europe. This was neglected in Anderson and Tushman (1990) original study. They defined innovation as the first piece sold of flat glass made by the new technology in the U.S. Research on the impacts of technological changes based on their model needs to be extended across international markets. This study of the diffusion of float glass the Canadian market contributes to this. The proper analysis of the foreign innovation also indicates a lot of the social/political and organizational impact for Tushman and Rosenkopf’s (1992) study. Moreover, the manufacturing processes involved in producing nonassembled products are not necessarily simple, which makes their diffusion complicated. This issue merits further attention.

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Appendix 1. The arbiters of dominant design for float glass.

