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Evolving sophistication of trade patterns in a transition economy – machinery exports of Poland 1980–2009

Abstract: Polish history leads to an expectation of exceptional adaptability to changes in the international economic environment. In the period bigenning with Solidarity at Gdansk to the present, Poland has faced huge structural dislocations. Is there any objective indication that the structural changes needed to successfully compete as a full-fledged European Union member were forthcoming? This study examines the behavior of four separate measures of embodied "sophistication." Though methodologically unrelated, these disparate indices tell a common story of rapid and substantial progress in the "battlefield" of a new member of the European Union.
Keywords: Trade Patterns in a Transition Economy; Machinery and Transport Equipment; Exports; Poland; Solidarity; Structural Change; Sophistication Indices; Trade Specialization Index; Intra-Industry Trade; Shock Therapy; Revealed Comparative Advantage; Herfendahl-Hirschman Index; Standard International Trade Classification; Compositional Shifts; Data Aggregation; Dispersion; Market Power.
JEL codes: F0, F1, L0, L1, L6, N0, N6, O1, O52, P2, R1.

Introduction

A cursory examination of Poland's history suggests that the Polish society and economy would likely exhibit a relatively large resiliency to change. From the middle of the seventeenth century to the present, Poland found itself continually sliced up, and at times totally swallowed up by its neighbors, the Prussians, Russians and Austro–Hungary empires (and the Swedes). Then, in the mid twentieth century, again Poland was devoured by Germany and Soviet Russia, absorbed into the Third Reich, and following subsequent territorial adjustments, became a political and economic satellite of the Soviet empire. This suggests that again and again, Poland found itself affected by one or another border adjustment; adopting, dealing with, and adjusting

to constantly changing trade regimes. In other words, trade with any given neighboring province or town was likely to evolve into international trade at one time or another. This must have left a remarkably flexible ability to handle changes. In the nineteen eighties, once again Poland found itself facing a fundamental change in its political and economic environment. In short, one would expect the unusually high degree of adaptability to unexpected changes to translate into a high level of competitiveness in today's rapidly shifting economic scene.

In about forty years preceding this last change, Poland essentially played the economic role of a component in a state-trading system, the Council for Mutual Economic Assistance (COMECON), designed to ensure stability in the provision of inputs to the Soviet five-year plan needs. The change in the early 1980s was a dramatic one, as Poland then faced great potential gains and also risks of "privatization" at an international level. No longer did five-year plans dictate "norms." A guaranteed international market for its production no longer existed. Suddenly, Poland had to find its niche in the competitive and sophisticated markets of the European Union. One may have expected that the shift from the Soviet economic orbit to a trading partner and ultimately a member of the European Union (EU) would lead to a growth in the level of sophistication in Poland's exports.

This paper explores the data of Poland's exports of machinery and transport equipment (henceforth referred to as "machinery") for evidence of an increase in the level of sophistication in Poland's machinery exports. For a discussion explaining the focus on this particular product sector, see Appendix.

The concept of trade sophistication is rather difficult to conceptualize, and even more complicated to measure and quantify. Four methods are used in this paper to identify and track the degree of sophistication in Poland's exports during the critical transition period of 1980–2009. The first is the degree to which Poland's exports are focused on and specialized in the relatively sophisticated key product sector of 'machinery and transport equipment' (Standard International Trade Classification (SITC 7)). The second is the extent to which the degree of specialization grew within the key SITC 7 Sector. The third is the degree to which Intra Industry trade characterized the Polish machinery exports. Finally, the use of a recently developed 'Sophistication Index' developed by Lall and Weiss [2006] is analyzed.

The labor turmoil and the formation of 'Solidarity' in 1980 at Gdansk marked an important turning point for Poland. This date marked a major shift away from an externally controlled and constrained (state-trading) system to one with a relatively larger set of opportunities consistent with Poland's economic welfare. It is therefore logical to have expected that the new patterns of specialization which evolved after this date reflect the nature of the Polish and revealed their dynamic comparative advantage.

The next epochal shift may be argued to have occurred in 1990's. By 1990, Solidarity had swept parliamentary elections and the presidency. In that same year,

a 'shock therapy' program was initiated and carried out consistently during the early 1990s. It is argued that this period was characterized by a conscious shift to a democratic, market–oriented economy. The next key date marked in this study is the 21st Century, during which much of the transformation to a market–oriented economy had been largely completed. Poland joined the European Union, and gained access to EU structural funds in 2004.

The remainder of the paper is organized as follows. Section 1 describes the compositional shifts in export patterns of Poland using one digit SITC codes. Section 2 graphically details the compositional evolution by product sector. Section 3 concentrates on presenting the Polish intra–industry trade. Section 4 shows the top ten machinery exports of Poland for the years 1980, 1990, 1995, 2000, 2005 and the last year of the sample, 2009. Section 5 derives the degree of specialization of machinery exports of Poland. Section 6 deduces the degree of sophistication of machinery exports. Section 7 concludes.

1. Broad compositional shifts in Poland's export patterns

Table 1 identifies those products and product groups that reflected the major gains in Poland's international specialization during the decades between 1980 and 2009.

Table 1. A Survey of Poland's export composition 1980–2009

SITC REV.2	Description	Percent of all exports			
		1980	1990	2004	2009
0	food and live animals	5	13	7	9
1	beverages and tobacco	1	1	0	1
2	crude materials	6	9	3	2
3	mineral fuels etc	20	12	6	2
4	animal based products	0	0	0	0
5	chemicals	6	9	6	7
6	basic manufactures	18	28	25	20
7	machinery	40	20	30	40
8	misc manufactures	10	7	21	14
9	goods not classed	0	0	2	2

Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics.

In 1980, Poland's three predominant export sectors were machinery (SITC 7), 40% of all commodity exports, mineral fuels (oil based) (SITC 3), 20%, basic manufactures (SITC 6), 18%, and miscellaneous manufactures (SITC 8), 10%. Notable was the relative dearth of Polish exports of primary, relatively unsophisticated products (SITC 0, 1, 2, 4). In short, Poland provided the Soviet Bloc with two main SITC codes, one being machinery and the other minerals and oil products.

During the decade 1980–1990 following the labor disturbances that signaled the imminent collapse of the Soviet system, the major changes in Poland's export composition suggest a retreat from both specialization and sophistication. The primary exports of food and live animals increased from 5% to 13% of all Poland's exports. The only sectors that demonstrated a clear relative increase were SITC 2 (crude materials) which grew from 6% to 9%; and SITC 6, basic manufactures, which grew from 18% to 28 % of all exports. In the relatively sophisticated sector, the SITC 7, machinery declined by 50%, from 40% to 20%, of all exports. In short, the immediate reaction to the collapse of the Soviet system was a shift away from sophisticated exports. A rough interpretation is largely explained by the shift of destination markets for Poland's exports away from the Soviet Union and other Eastern European countries to Germany and Western Europe. A simple classical paradigm would note that relative to the new configuration of markets, Poland had relatively less of a comparative advantage in more sophisticated products. Accordingly, the decade of the eighties saw a decline in the sophistication composition of Poland's exports.

The period following 1990 until 2004 experienced a major reversal of the export compositional shift of the 1980s. This period saw a growing specialization in the relatively sophisticated machinery categories. During this period, exports of food, fuel, and crude materials retreated as contributors to Poland's exports. The only two sectors that experienced relative growth were machinery (SITC 7) – from 20% to 30% of total Poland's exports, and miscellaneous manufactures (SITC 8), from 7% to 21%. The relatively less sophisticated, and less diversified sector SITC 6 maintained a relatively stable weight in Poland's exports during this period. Clearly, the relative homogeneous, commoditized primary and less sophisticated exports, in terms of natural resource input, lost relative weights in favor of more sophisticated and diversified product groups (SITC 7 and SITC8). This was a sea-change in comparison to the immediate changes that characterized the decade following the traumatic break with the past of the 1980s. Thus, during this period, Poland was rapidly finding its comparative advantage in diversified manufactures, and relatively complex and sophisticated machinery exports. In the period preceding the 1980s, Poland had been considered by its Soviet market to be a relatively technologically advanced partner. Though Poland possessed an unsophisticated productive infrastructure relative to Western Europe, it had a history of industrial machinery exports, and rapidly adjusted to the diversified and sophisticated trading partners in Germany and Western Europe.

During the recent period of 2004–2009, Poland became increasingly integrated into the European Union, and demonstrated an increasing degree of specialization and sophistication. Relative exports growth was limited to one sector, SITC 7, machinery, (from 30% to 40%). In 1980, the key destinations for Polish machinery, close to 90%, had been the markets of Soviet and Eastern Europe. By 2009, more than one quarter of its exports were now directed to Germany and other Western European countries. Nevertheless, the relative weight of the machinery sector (SITC 7) was practically identical in 2009 to what it had been in 1980. For a detailed analysis of investment in the Polish manufacturing in the years 1997–2007 and the role of financial positions and general credit risk, see in this journal, Kowalski, Wallusch, and Zenka [2010]. For an overview of the fundamental market reforms in Poland see this Journal, Poznań University of Economic Review [2010].

2. Compositional shifts by product sector of Poland's exports

The following figures, Figure 1 through Figure 10 indicate the levels and changes in relative (value) weights of each of the major export sectors of Poland from 1980 to 2009. They enable the examination of the compositional shifts over time not only between the various (SITC) trade sectors, but within each of them. The figures present the compositional share in all commodity exports by individual product sectors.

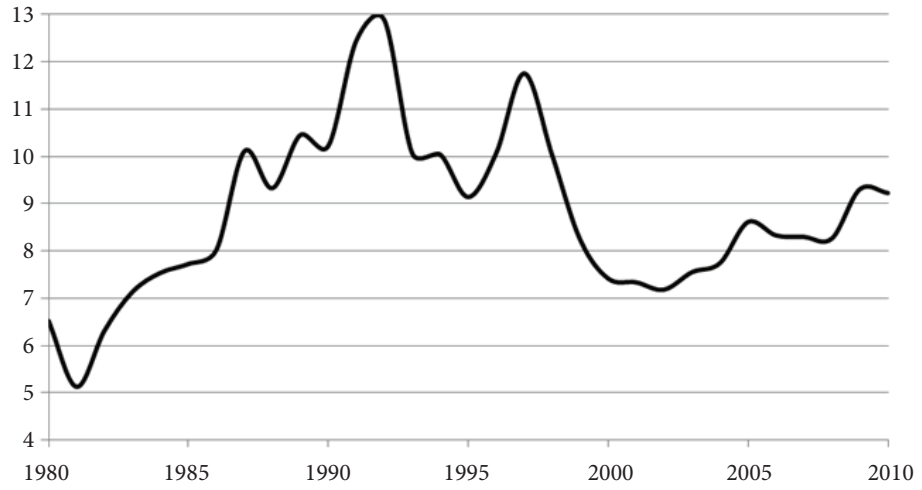

Figure 1. Share of food and live animals (SITC = 0) in total commodity exports
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

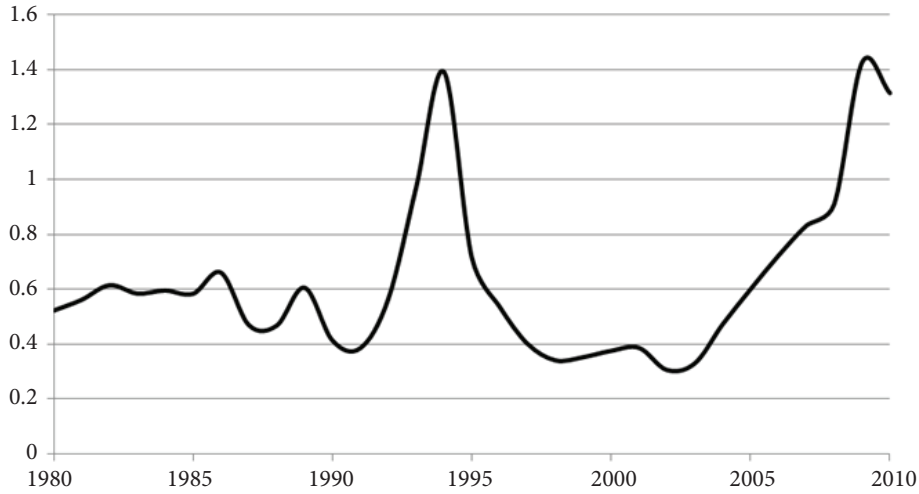

Figure 2. Percent of beverages and tobacco (SITC = 1) in total commodity exports
Source: Own Calculations Based on International Merchandise Trade Statistics, United Nations Statistics

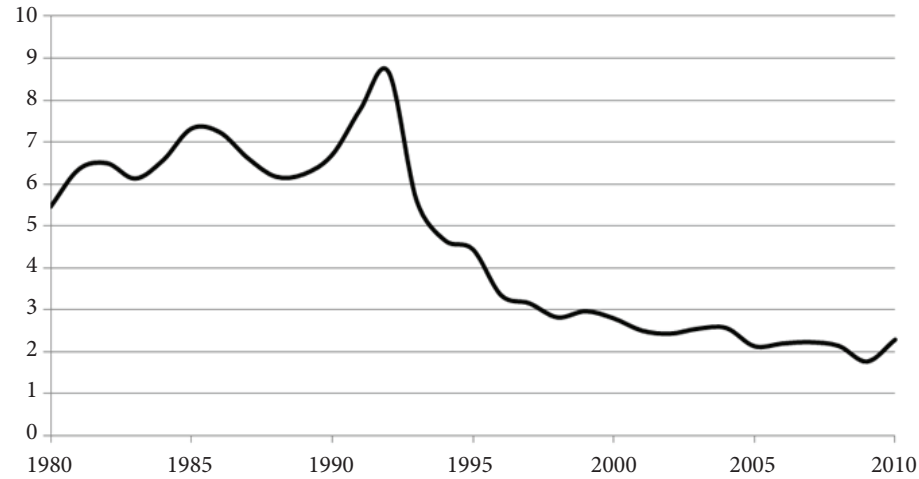

Figure 3. Percent of crude materials (SITC = 2) in total commodity exports
Source: Own Calculations Based on International Merchandise Trade Statistics, United Nations Statistics

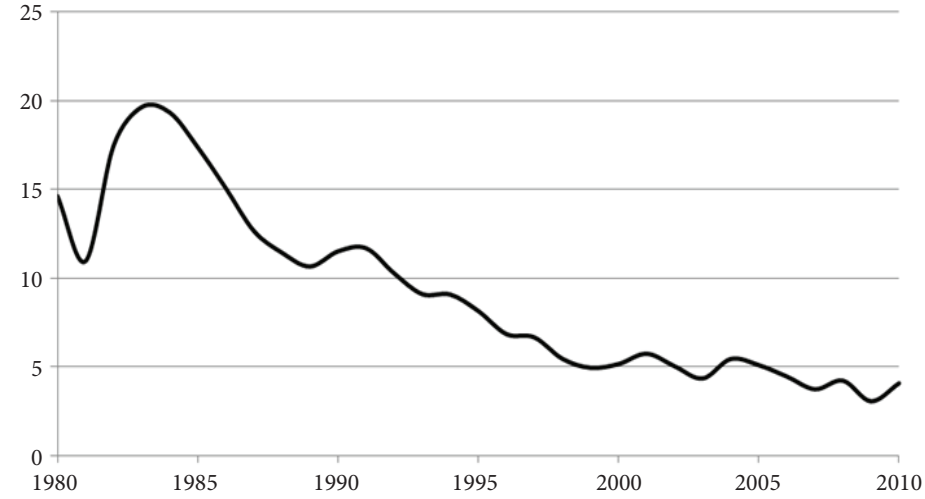

Figure 4. Percent of mineral, fuels, etc. (SITC = 3) in total commodity exports
Source: Own Calculations Based on International Merchandise Trade Statistics, United Nations Statistics

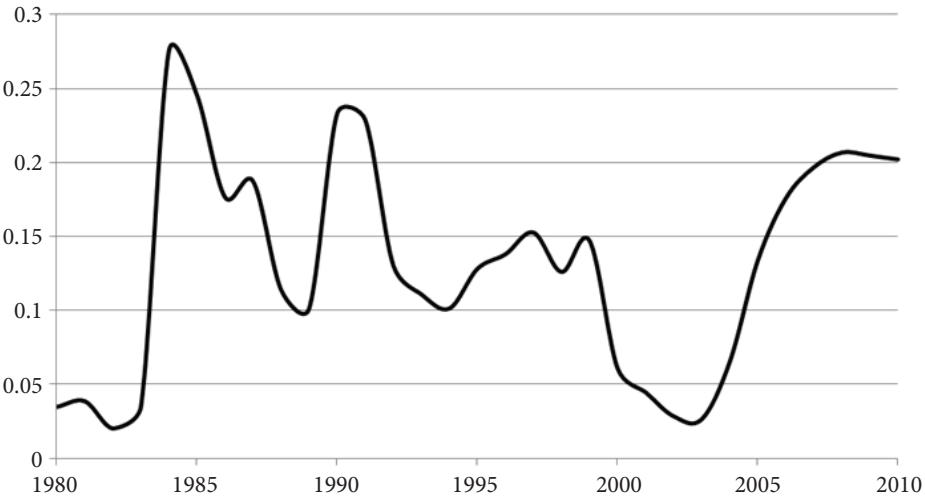

Figure 5. Percent of animal based products (SITC = 4) in total commodity exports
Source: Own Calculations Based on International Merchandise Trade Statistics, United Nations Statistics

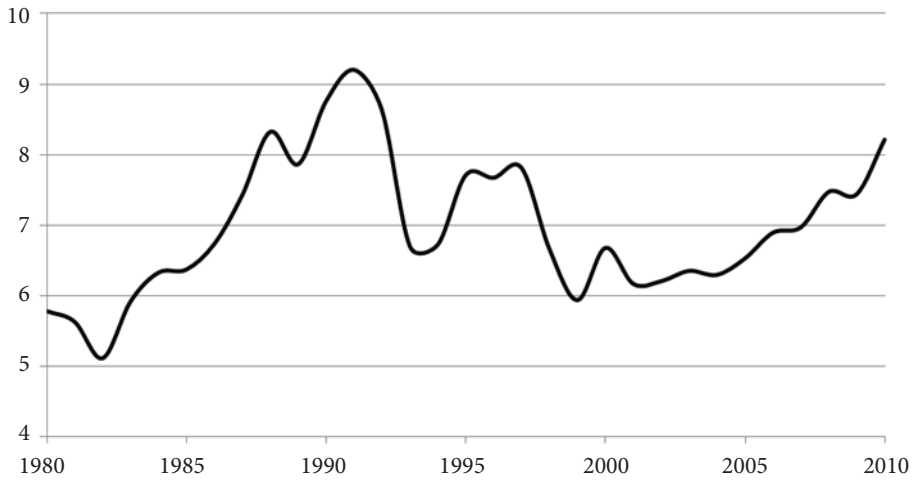

Figure 6. Percent of chemicals (SITC = 5) in total commodity exports
Source: Own Calculations Based on International Merchandise Trade Statistics, United Nations Statistics

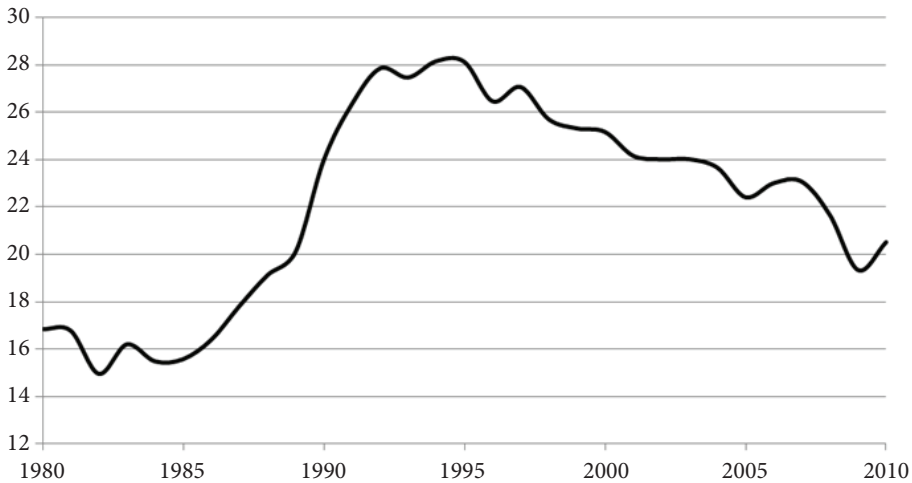

Figure 7. Percent of basic manufactures (SITC = 6) in total commodity exports
Source: Own Calculations Based on International Merchandise Trade Statistics, United Nations Statistics

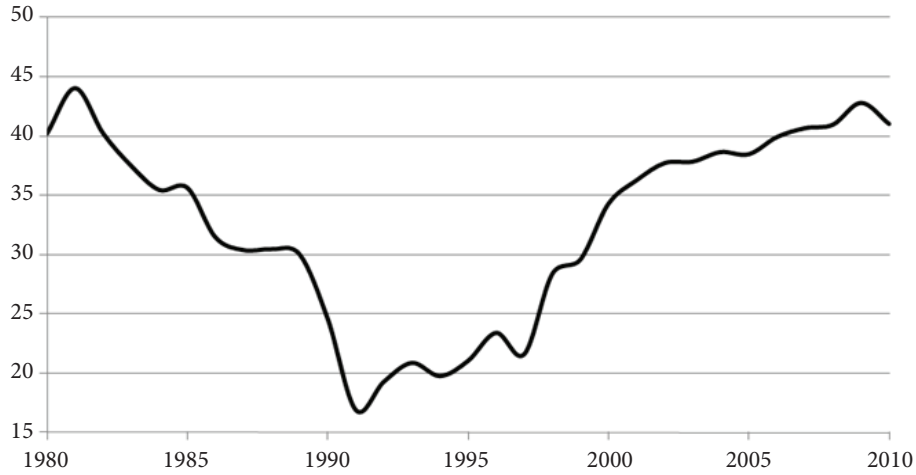

Figure 8. Percent of machinery (SITC = 7) in total commodity exports
Source: Own Calculations Based on International Merchandise Trade Statistics, United Nations Statistics

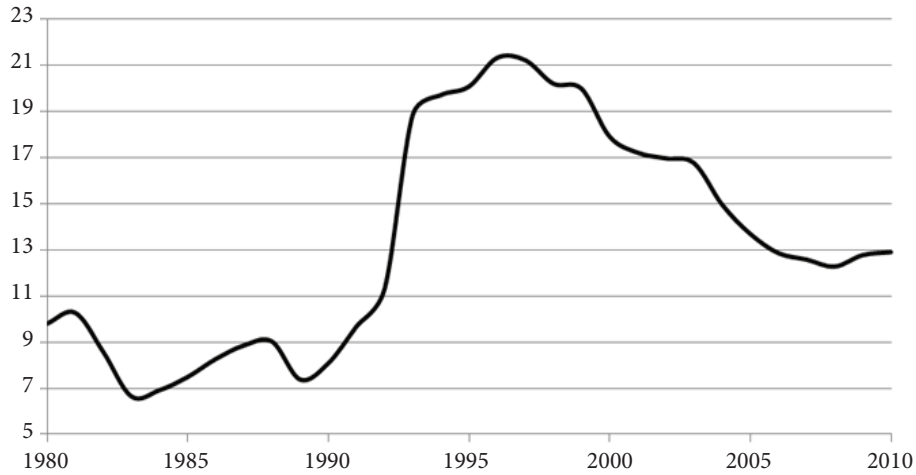

Figure 9. Percent of miscellaneous manufactures (SITC = 8) in total commodity exports
Source: Own Calculations Based on International Merchandise Trade Statistics, United Nations Statistics

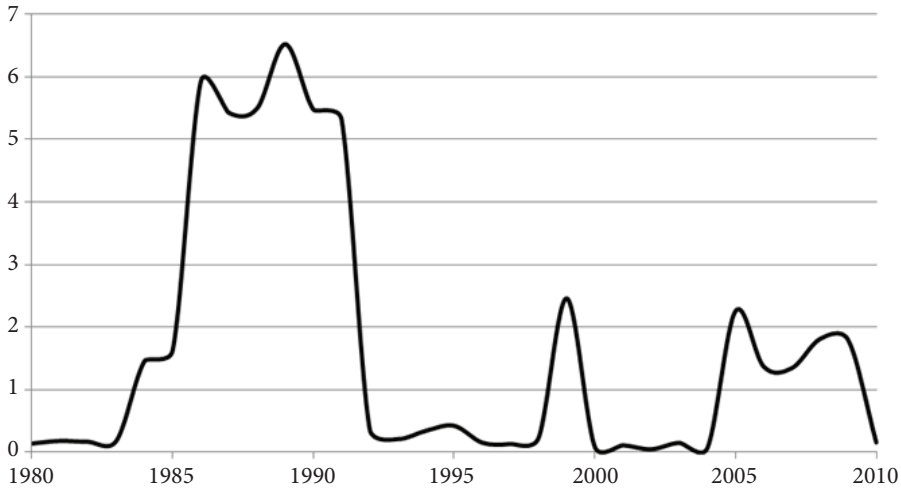

Figure 10. Percent of goods not classified (SITC = 9) in total commodity exports
Source: Own Calculations Based on International Merchandise Trade Statistics, United Nations Statistics

A commonality that is found to characterize each and every product sector is the sharp break in the dynamic pattern of the 1980s from that following 1990. These graphs are created using observations at relatively high levels of aggregation, i.e. one-digit SITC Rev 2. The presentations and discussion of subsequent findings in this paper utilize quite detailed, disaggregated data at the four-digit SITC Rev 2. Of especial relevance to the competitiveness of Poland's economy is the clear shift to machinery exports (SITC 7) in its exports, since the early 1990's.

An important insight in International Trade Theory, pioneered by I.B. Kravis, is that major manifestations of competitiveness associated with the modern era have been embodied in a focus on exports of machinery and transport equipment (SITC 7). This subset has consistently been found to be a key to international competitiveness, as machinery exports tend to continually embody technological innovations. For a citation here, see Appendix below.

3. Patterns of Polish intra-industry trade 1980–2009

One of the important features of modern international trade theory is intra-industry trade (IIT). Beginning in the 1960s, the presence of two-way trade among countries within individual product categories became noticeable [Grubel 1967]. This intra-

industry trade has gone from being a curiosity to a major component of international trade. Whether the IIT phenomenon is of the "horizontal" or "vertical" type, it has generally been identified with relatively high levels of economic sophistication. Hence, most of the studies dealing with IIT find it characteristic of country trade for those countries that belong to the Organization for Economic Co-operation and Development (OECD). We therefore take this IIT measure as a proxy for the level of sophistication of the revealed comparative advantage of Poland.

A voluminous literature on IIT exists. The seminal work is by Helpman and Krugman [1985]. Earlier contributions include Graham [1923], Linder [1961], Ethier [1979, 1982a, 1982b] and the collection of papers edited by Kierzkowski [1984]. Later contributions include Porter [1990] and Saxenian [1994]. More recently, Kim and Niem [2011] study the impact of preference diversity and relative country size on intra-industry trade (IIT) in an industry with a vertically differentiated product. Niem and Kim [2010] provide a simple theoretical model to investigate determinants of the vertical IIT based on Bertrand price competition. Lim [2011] asks the question, when fragmentation increases intra-industry trade (IIT) in interregional trade, do we expect to see the increasing roles of interregional trade toward the equilibrium condition in regional labor markets?

Fainstein and Netsunajev [2011] study intra-industry trade development in the Baltic States. Sawyer, Sprinkle and Tochkov [2010] look at Patterns and Determinants of Intra-industry Trade in 22 countries in East, Southeast, South, and Central Asia in 2003. Aydin [2010] examines the interaction between foreign direct investment (FDI) and intra-industry trade (IIT) in Turkey for the year of 2005. Fainstein and Netsunajev [2010] show that vertical IIT plays a dominant role in Estonian-EU IIT flows. Shares of total, vertical, and horizontal IIT have grown rapidly since 2004, the year of accession to the EU. Shahbaz and Leitao [2010] detail Pakistan's experience with ITT. Celi [2010] provides empirical explanation of IIT for the U.K. Ferto and Soos [2010] look at ITT and adjustment costs in the first phase of transition by comparing the experiences of Hungary and Poland.

Yoshida, Carlos-Leitao and Faustino [2009] conduct a study on intra-industry trade and foreign direct investment between Japan and European countries, including both old and new EU members, as well as emerging central and eastern European countries. Furthermore, Sen, Saray and Karagoz [2009] use a panel data analysis to investigate ITT between Turkey and OECD Countries. Veeramani [2009] analyses the effects of trade barriers and multinationals on the intensity of intra-industry trade (IIT) in a panel of Indian manufacturing industries from 1988 to 1999.

Other studies concentrate on a particular industry or a few sectors of the economy. Recent contributions are, Turkcan [2011] who studies intra-industry trade in the Austria's auto-parts industry, Turkcan and Ates [2011] study the U.S.'s auto-parts industry. Turkcan and Ates [2009] examine the composition of trade patterns, and development of intra-industry trade (IIT) between the U.S. and its 37 trading part-

ners in the auto-industry for the years 1989–2006. Marks [2009] utilizes a case-study approach to study intra-industry trade and adjustment costs in the Australian textile, footwear and motor vehicle industries. It is noteworthy that Gorynia, Jankowska and Owczarzak [2007], in this journal, study intra-industry trade for the furniture cluster in Wielkopolska. They find that the companies under study are reluctant to enter into cooperative relationships, especially with competitors. These companies fail to see either the benefits accruing from cooperation with rivals or a connection between locally available resources and their competitive position. This in contrast to Tsai [2005] who finds in his research on Taiwanese high-tech companies that intra and inter-industrial spillover effects in the field of research and development (R&D) have a greater significance from the viewpoint of production growth than individual companies' efforts in the field of R&D do. It is important to cite the works of Chow, Kellman and Shachmurove [1999] who test intra-industry trade using the Linder hypothesis in pacific newly industrialized countries, and those of Chow, Kellman and Shachmurove [1994] who analyze East Asian newly industrialized countries manufactured intra-industry trade for the years 1965–1990. I would have to look up the formal citation rules, but I would think there is a way to consolidate the 1999 and 1994 citations, since the authors are the same. The repetition of manufactured intra-industry trade is redundant if they did the same thing just for different regions in the two papers.

However, this extensive literature has focused almost exclusively on explaining the causes of IIT. This emphasis has left a puzzling gap in the literature. Specifically, it is almost impossible to determine the level of IIT for a particular country. Furthermore, there is almost no information on the level of IIT at the industry level either globally or by country. In this paper we provide estimates of IIT for Poland. Further, we provide the levels, and changes over time in the IIT measure for each of ten different SITC commodity groups.

Figure 11 through Figure 21 present the total IIT of Poland, for each year from 1980 to 2009, and the IIT for each of the ten product categories SITC 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. These calculations are performed by using the formula pioneered by Grubel and Lloyd [1971; 1975]:

$$\text{IIT Index} = 1 - \sum \frac{\left| x_i - M_i \right|}{x_i + M_i}$$

where Xi denotes the export and Mi the import of good *i*.

If IIT index equals 1, there is only intra-industry trade, no inter-industry trade. Conversely, if the index is equal to zero, there is no intra-industry trade, only inter-industry trade.

This is the common equation used to calculate IIT in the literature. For example, Haq and Meilke [2011] use the Grubel and Lloyd (GL) index as the dependent variable to investigate the role of the Linder effect in explaining the trade of 37

differentiated agri-food and beverage products across 52 developed and developing countries from 1990 to 2000. Leitao [2011] applies the Grubel and Lloyd statistic and shows that that the tourism services are important for a small economy such as Portugal. He finds that the intra-industry trade is very significant between Portugal and the following countries: Spain, USA, Italy, Greece, Turkey and Canada. Zhang, Li, Yang, and Du [2011] study the characteristics of the global pharmaceutical industry value chain and China's position in it, using among other statistics, the Grubel and Lloyd (GL) index.

Eshleman and Kotcherlakota [2010] study the EU-India trade using the Grubel-Lloyd method to calculate intra-industry trade index numbers. They find a relatively high degree of intra-industry trade between India and the EU, especially in more capital intensive industries, but no significant trend toward increased or decreased intra-industry trade overall over the 9-year period of 2000 to 2008.

Similarly, Din, Ghani and Qadir [2009] look at recent experience and future prospects of Pakistan's trade with China. They find that bilateral trade between the two countries is heavily tilted in favor of China and that this situation may persist in the short term. Das [2009] provides measures of Grubel-Lloyd intra-industry trade indexes for the world economies. Gebreselasie and Jordaan [2009] use the GL index to study intra-industry trade in the manufacturing sector of South Africa. Garanina [2009] studies the pattern of specialization in manufactures trade since 1998 in Russia. She shows that Russia is globally disadvantaged in manufactures trade vis-à-vis the EU and China, and advantaged in trade within the Commonwealth of Independent States (CIS). Russia is managing to expand its manufactured exports to other CIS countries. However, it is gradually losing its role of main supplier of capital goods in the post-Soviet space. Grigorovici [2009] analyses the degree of specialization in Romania's services trade. Saadawi, Kellman, and Shachmurove [1996] explore import vulnerability in defense-related industries. It is noteworthy that Mińska-Struzik and Rynarzewski [2006] analyse in this journal the strength and the character of trade linkages within the European Union for the year 2004 using the Grubel and Lloyd (GL) index.

Figure 11 presents the IIT level for Poland, calculated at the two-digit SITC level of aggregation. Figure 12 through Figure 21 repeat the calculation for each of the ten SITC product sectors. Note that the IIT index ranges from a zero (no two-way trade), to a value of unity (1), indicating 100% of all trade for that product sector may be characterized as two way trade.

Figure 11 shows that from 1980 to 1990, the level of IIT remained relatively stagnant. However, from 1990 to 2009, an upward trend in IIT levels is evident. The question that must be answered is whether the patterns noted in Figure 11 are typical throughout the various export sectors, or whether they represent a compositional shift in the direction of sectors with rising IIT levels since 1990. An examination of the individual sectoral IIT patterns in Figures 12–21 finds that the aggregated pat-

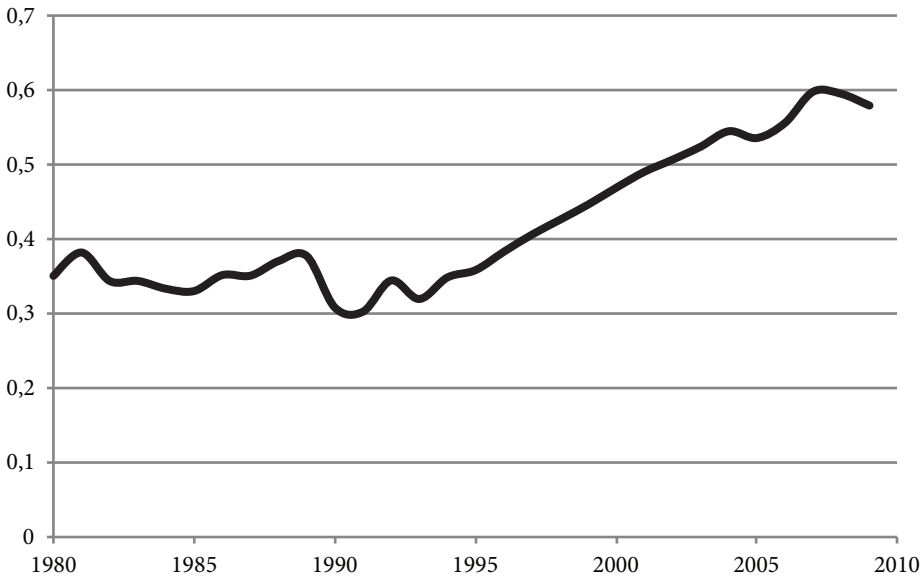

Figure 11. Poland Intra-Industry Trade (4-digit SITC classification) 1980–2009
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

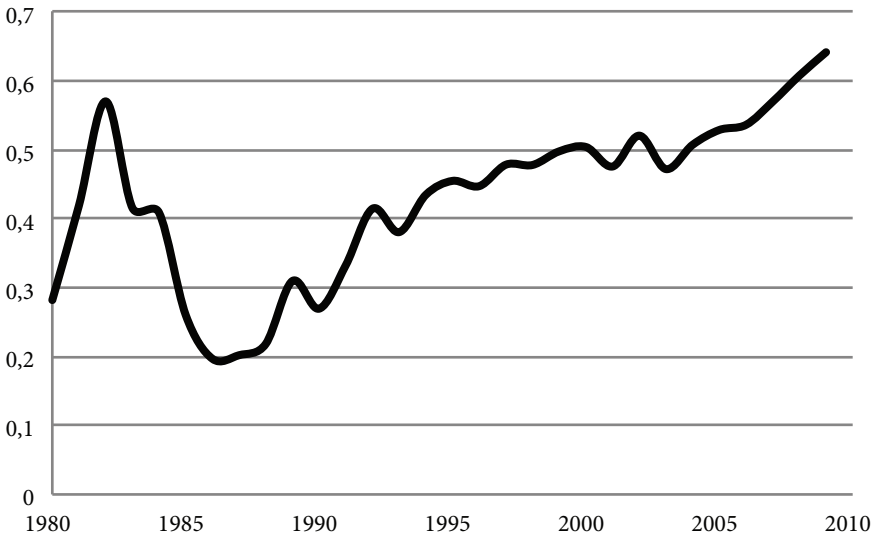

Figure 12. Poland Intra Industry Indices by one-digit SITC category for year 1980–2009 food and animals (SITC = 0)
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

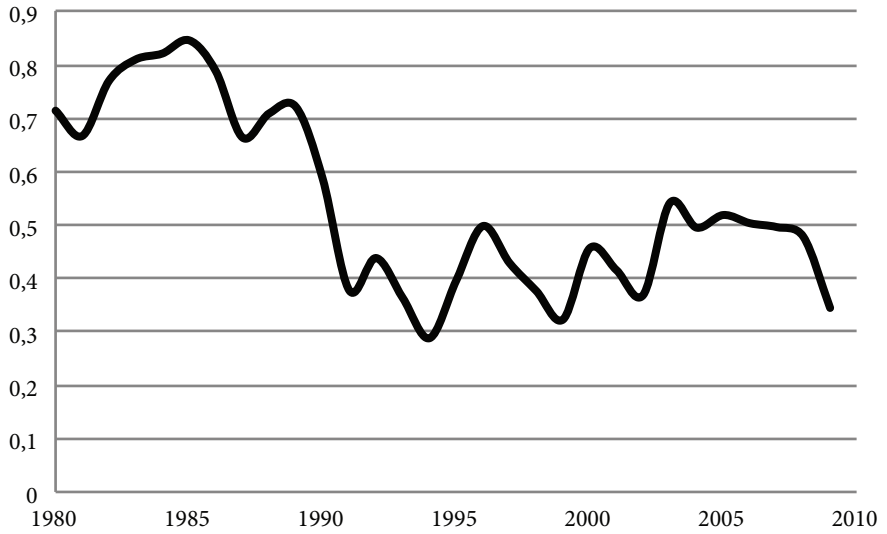

Figure 13. Poland Intra Industry Indices by one-digit SITC category for year 1980–2009 beverages and tobacco (SITC = 1)
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

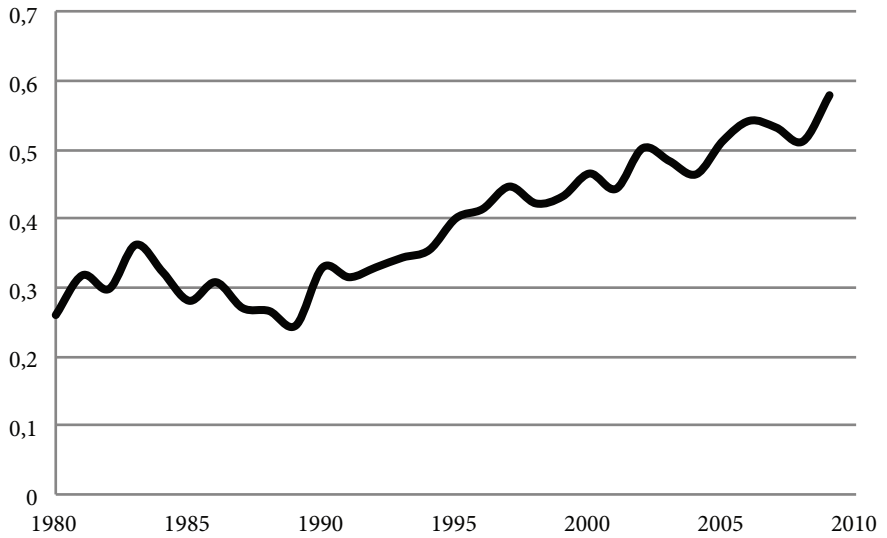

Figure 14. Poland Intra Industry Indices by one-digit SITC category for year 1980–2009 crude materials (SITC = 2)
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

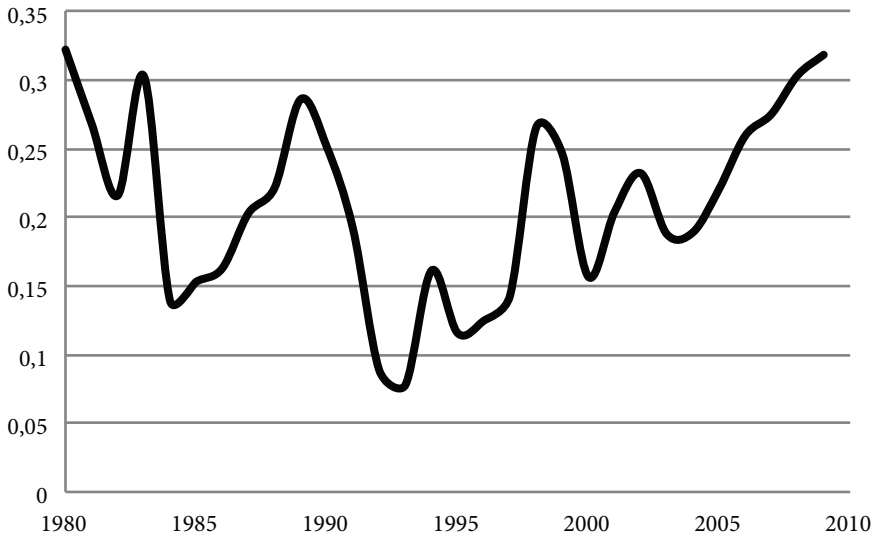

Figure 15. Poland Intra Industry Indices by one-digit SITC category for year 1980–2009 mineral, fuels, etc. (SITC = 3)
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

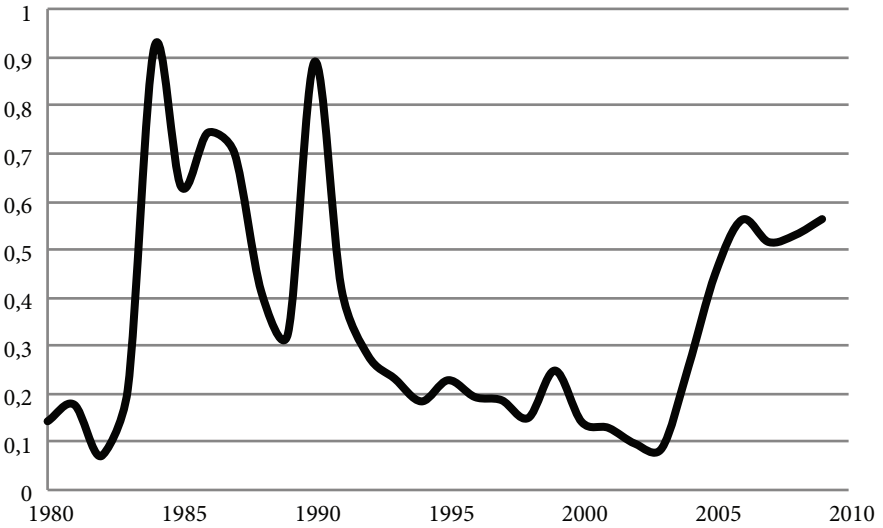

Figure 16. Poland Intra Industry Indices by one-digit SITC category for year 1980–2009 an-imal based products (SITC = 4)
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

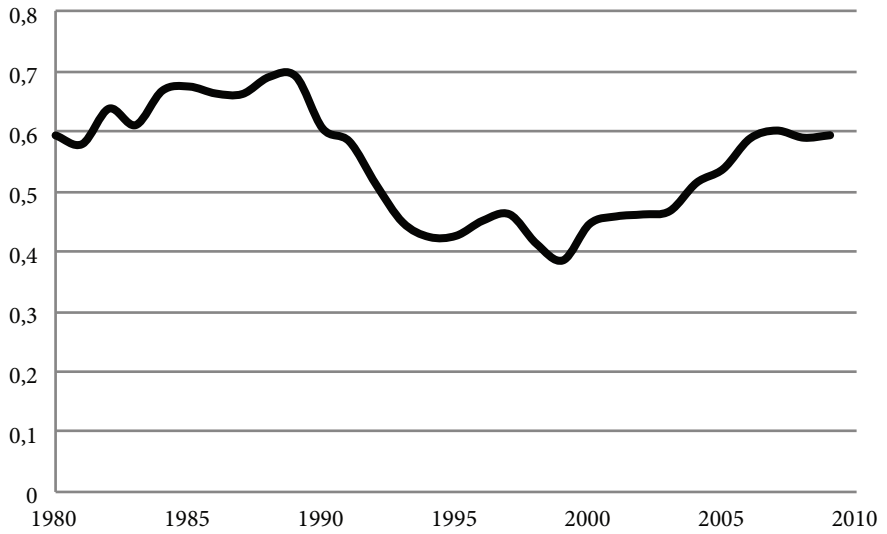

Figure 17. Poland Intra Industry Indices by one-digit SITC category for year 1980–2009 chemicals (SITC = 5)

Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

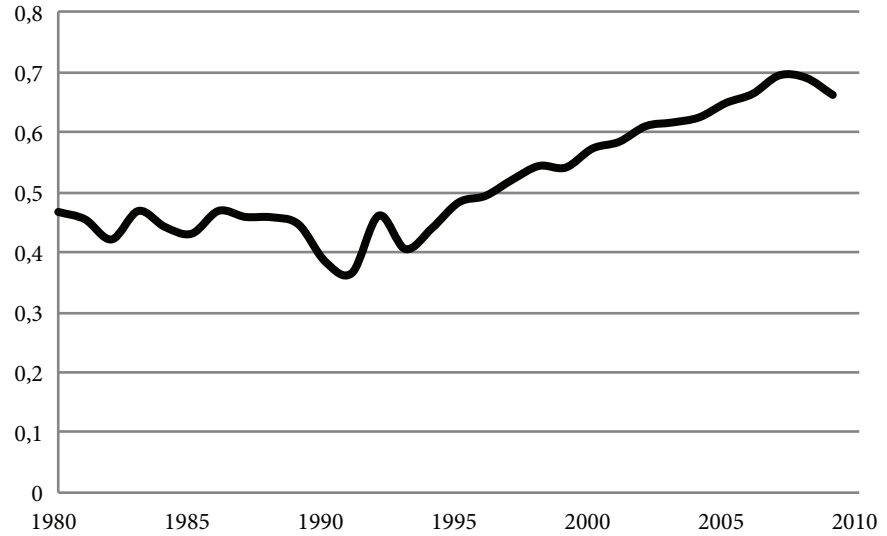

Figure 18. Poland Intra Industry Indices by one-digit SITC category for year 1980–2009 basic manufactures (SITC = 6)

Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

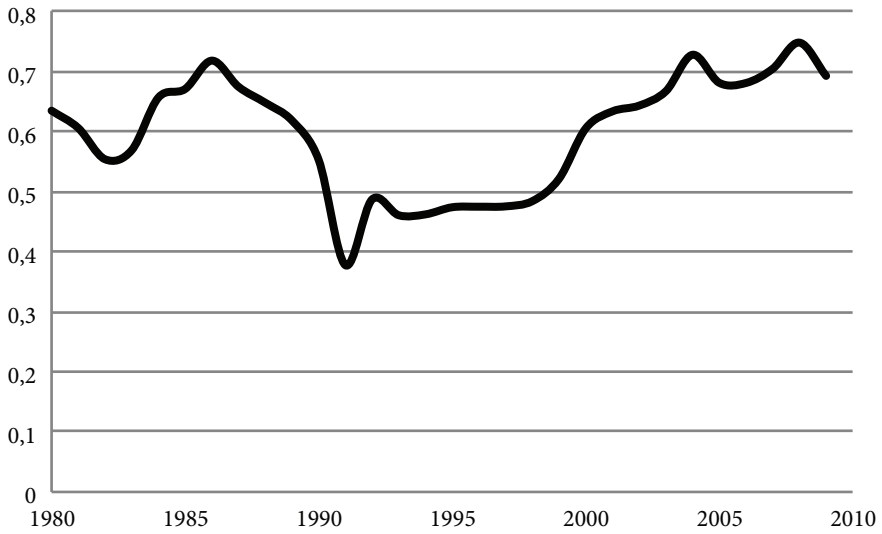

Figure 19. Poland Intra Industry Indices by one-digit SITC category for year 1980–2009 ma-chinery (SITC = 7)
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

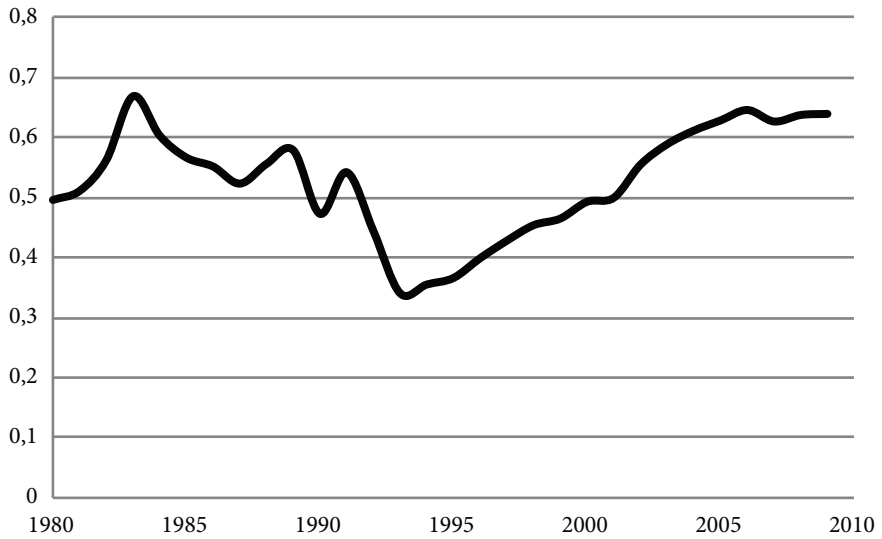

Figure 20. Poland Intra Industry Indices by one-digit SITC category for year 1980–2009 mis-cellaneous manufactures (SITC = 8)
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

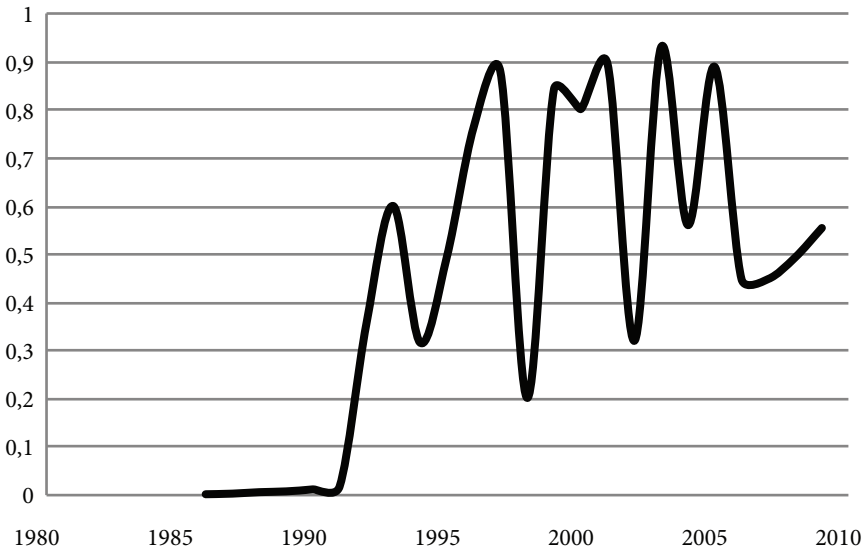

Figure 21. Poland Intra Industry Indices by one-digit SITC category for year 1980–2009 goods not classified (SITC = 9)
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

tern in Figure 11 is not replicated in the case of each and every product sector. It is, however, clear that the general all-Poland pattern in Figure 11 is found replicated in two of the relatively sophisticated, and the most rapidly growing sectors, notably that of SITC 7 that grew from 20% of all Poland's commodity exports in 1990 to 40% in 2009. Hence, the pattern reflects both the IIT pattern in SITC 7 (machinery), and the compositional shift from 1990 in favor of machinery as a rapidly growing component in Poland's trade. Both the shift toward the relatively sophisticated product sector 'machinery' and the intra-sector shift within the 'machinery' sector lead to expectations of high levels of competitiveness of Poland in its international markets during the current period as markets emerge from the effects of the global crisis. On the financial crises see, for example, Kowalski and Shachmurove [2011], Shachmurove T. and Shachmurove, Y. [2011], and Shachmurove [2010a, 2010b and 2011].

4. Top Ten Machinery Exports of Poland 1980–2009

Table 2 identifies the ten specific machinery products whose exports constituted the largest value in each of the years 1980, 1990, 1995, 2000, 2005 and 2009.

Table 2. Ten Top Machinery Exports by year 1980–2009

Year	SITC	Export (USD 000)	Description
1980	7783	61,661,440.00	Automotive electrical equipment and parts thereof, nes*
1980	7782	54,140,712.00	Electric filament lamps and discharge lamps arc-lamps
1980	7648	36,572,752.00	Telecommunications equipment, nes
1980	7788	28,871,294.00	Other electrical machinery and equipment, nes
1980	7643	10,571,164.00	Television, radio-broadcasting transmitters, etc
1980	7518	5,267,232.00	Office machines, nes
1980	7784	4,928,335.00	Electro-mechanical hand tools, and parts thereof, nes
1980	7415	4,004,299.00	Air conditioning machines and parts thereof, nes
1980	7511	3,877,240.00	Typewriters cheque-writing machines
1980	7641	812,707.00	Electrical line telephonic and telegraphic apparatus
1990	7782	46,779,496.00	Electric filament lamps and discharge lamps arc-lamps
1990	7788	30,181,665.00	Other electrical machinery and equipment, nes
1990	7783	14,514,442.00	Automotive electrical equipment and parts thereof, nes
1990	7648	13,753,583.00	Telecommunications equipment, nes
1990	7641	5,234,288.00	Electrical line telephonic and telegraphic apparatus
1990	7415	5,201,719.00	Air conditioning machines and parts thereof, nes
1990	7643	3,882,640.00	Television, radio-broadcasting transmitters, etc
1990	7518	1,461,113.00	Office machines, nes
1990	7784	1,372,719.00	Electro-mechanical hand tools, and parts thereof, nes
1990	7511	1,303,864.00	Typewriters cheque-writing machines
1995	7932	950,377,024.00	Ships, boats and other vessels
1995	7810	658,944,000.00	Passenger motor vehicles (excluding buses)
1995	7731	268,716,992.00	Insulated electric wire, cable, bars, etc
1995	7821	179,848,992.00	Motor vehicles for the transport of goods or materials
1995	7761	164,968,000.00	Television picture tubes, cathode ray
1995	7782	132,884,000.00	Electric filament lamps and discharge lamps arc-lamps
1995	7491	93,456,000.00	Ball, roller or needle roller bearings
1995	7234	87,633,000.00	Construction and mining machinery, nes
1995	7788	84,431,000.00	Other electrical machinery and equipment, nes
1995	7861	72,803,000.00	Trailers and transports containers
2000	7810	1,462,904,960.00	Passenger motor vehicles (excluding buses)

Year	SITC	Export (USD 000)	Description
2000	7932	889,832,000.00	Ships, boats and other vessels
2000	7611	635,113,984.00	Television receivers, color
2000	7731	614,838,016.00	Insulated electric wire, cable, bars, etc
2000	7821	446,376,992.00	Motor vehicles for the transport of goods or materials
2000	7782	194,356,992.00	Electric filament lamps and discharge lamps arc-lamps
2000	7761	179,116,000.00	Television picture tubes, cathode ray
2000	7491	144,314,000.00	Ball, roller or needle roller bearings
2000	7931	122,165,000.00	Warships
2000	7758	121,121,000.00	Electro-thermic appliances, nes
2005	7810	5,379,791,288.00	Passenger motor vehicles (excluding buses)
2005	7731	1,943,587,577.00	Insulated electric wire, cable, bars, etc
2005	7611	1,791,935,883.00	Television receivers, color
2005	7821	1,052,248,109.00	Motor vehicles for the transport of goods or materials
2005	7751	599,706,129.00	Household laundry equipment, nes
2005	7831	511,849,590.00	Public service type passenger motor vehicles
2005	7491	372,133,414.00	Ball, roller or needle roller bearings
2005	7783	345,504,823.00	Automotive electrical equipment and parts thereof, nes
2005	7711	300,709,094.00	Transformers, electrical
2005	7641	299,422,873.00	Electrical line telephonic and telegraphic apparatus
2009	7810	9,670,629,651.00	Passenger motor vehicles (excluding buses)
2009	7611	6,631,951,168.00	Television receivers, color
2009	7731	1,815,552,754.00	Insulated electric wire, cable, bars, etc
2009	7522	1,354,455,029.00	Complete digital data processing machines
2009	7751	1,292,010,589.00	Household laundry equipment, nes
2009	7821	1,281,142,379.00	Motor vehicles for the transport of goods or materials
2009	7831	1,141,301,272.00	Public service type passenger motor vehicles
2009	7783	657,105,531.00	Automotive electrical equipment and parts thereof, nes
2009	7753	523,906,680.00	Domestic dishwashing machines
2009	7711	498,596,539.00	Transformers, electrical

* Not elsewhere specified.

Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics.

Table 3. Share of ten top machinery exports out of total exports and total machinery exports and by year 1980–2009

Year	SITC	Description	Share out of total exports (in %)	Share out of total machinery (in %)
1980	7783	Automotive electrical equipment and parts thereof, nes*	0.927	9.744
1980	7782	Electric filament lamps and discharge lamps arc-lamps	0.814	8.556
1980	7648	Telecommunications equipment, nes	0.550	5.780
1980	7788	Other electrical machinery and equipment, nes	0.434	4.563
1980	7643	Television, radio-broadcasting transmitters, etc	0.159	1.671
1980	7518	Office machines, nes	0.079	0.832
1980	7784	Electro-mechanical hand tools, and parts thereof, nes	0.074	0.779
1980	7415	Air conditioning machines and parts thereof, nes	0.060	0.633
1980	7511	Typewriters cheque-writing machines	0.058	0.613
1980	7641	Electrical line telephonic and telegraphic apparatus	0.012	0.128
1990	7782	Electric filament lamps and discharge lamps arc-lamps	0.740	15.620
1990	7788	Other electrical machinery and equipment, nes	0.477	10.078
1990	7783	Automotive electrical equipment and parts thereof, nes	0.230	4.846
1990	7648	Telecommunications equipment, nes	0.218	4.592
1990	7641	Electrical line telephonic and telegraphic apparatus	0.083	1.748
1990	7415	Air conditioning machines and parts thereof, nes	0.082	1.737
1990	7643	Television, radio-broadcasting transmitters, etc	0.061	1.296
1990	7518	Office machines, nes	0.023	0.488
1990	7784	Electro-mechanical hand tools, and parts thereof, nes	0.022	0.458
1990	7511	Typewriters cheque-writing machines	0.021	0.435
1995	7932	Ships, boats and other vessels	4.181	19.768
1995	7810	Passenger motor vehicles (excluding buses)	2.899	13.706
1995	7731	Insulated electric wire, cable, bars, etc	1.182	5.589
1995	7821	Motor vehicles for the transport of goods or materials	0.791	3.741
1995	7761	Television picture tubes, cathode ray	0.726	3.431
1995	7782	Electric filament lamps and discharge lamps arc-lamps	0.585	2.764
1995	7491	Ball, roller or needle roller bearings	0.411	1.944
1995	7234	Construction and mining machinery, nes	0.386	1.823
1995	7788	Other electrical machinery and equipment, nes	0.371	1.756
1995	7861	Trailers and transports containers	0.320	1.514

Year	SITC	Description	Share out of total exports (in %)	Share out of total machinery (in %)
2000	7810	Passenger motor vehicles (excluding buses)	4.627	13.551
2000	7932	Ships, boats and other vessels	2.815	8.243
2000	7611	Television receivers, colour	2.009	5.883
2000	7731	Insulated electric wire, cable, bars, etc	1.945	5.695
2000	7821	Motor vehicles for the transport of goods or materials	1.412	4.135
2000	7782	Electric filament lamps and discharge lamps arc-lamps	0.615	1.800
2000	7761	Television picture tubes, cathode ray	0.567	1.659
2000	7491	Ball, roller or needle roller bearings	0.456	1.337
2000	7931	Warships	0.386	1.132
2000	7758	Electro-thermic appliances, nes	0.383	1.122
2005	7810	Passenger motor vehicles (excluding buses)	6.019	15.638
2005	7731	Insulated electric wire, cable, bars, etc	2.175	5.650
2005	7611	Television receivers, colour	2.005	5.209
2005	7821	Motor vehicles for the transport of goods or materials	1.177	3.059
2005	7751	Household laundry equipment, nes	0.671	1.743
2005	7831	Public service type passenger motor vehicles	0.573	1.488
2005	7491	Ball, roller or needle roller bearings	0.416	1.082
2005	7783	Automotive electrical equipment and parts thereof, nes	0.387	1.004
2005	7711	Transformers, electrical	0.336	0.874
2005	7641	Electrical line telephonic and telegraphic apparatus	0.335	0.870
2009	7810	Passenger motor vehicles (excluding buses)	7.077	16.677
2009	7611	Television receivers, colour	4.854	11.437
2009	7731	Insulated electric wire, cable, bars, etc	1.329	3.131
2009	7522	Complete digital data processing machines	0.991	2.336
2009	7751	Household laundry equipment, nes	0.946	2.228
2009	7821	Motor vehicles for the transport of goods or materials	0.938	2.209
2009	7831	Public service type passenger motor vehicles	0.835	1.968
2009	7783	Automotive electrical equipment and parts thereof, nes	0.481	1.133
2009	7753	Domestic dishwashing machines	0.383	0.904
2009	7711	Transformers, electrical	0.365	0.860

* Not elsewhere specified.

Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics.

An examination of the respective top ten machinery exports reveals that during the 1980s, the introduction of new products was relatively slow. Of the top ten exported machinery products in 1990, only two were 'new', in the sense that they were not found in the top ten list of 1980 (telecommunications equipment nes., and electrical line telephonic and telegraphic apparatus). In other words, eight of the ten products in the top ten of 1990 were also in the top ten of 1980.

In the 1990s an entirely different pattern arises. The rate of change in new products in the decade of the 1990s indicates an entirely different phenomenon. Of the top ten machinery exports of 2000, each and every one of these ten was new! In other words, not one product in the top ten exports of 1990 appears in the list of the top ten Polish machinery exports in the year 2000. Clearly, this was a dynamic period in which growing levels of product sophistication were continually and rapidly introduced. Novel products incorporating new technologies became the norm in the mix of machinery exports as Poland entered the Twenty-First Century. When comparing the identities of products in the top ten Polish machinery exports in 2009 with the list for the year 2000, evidence is found of a continued wave of new product introduction and, presumably, of continual rapid technological 'newness', as six of the top ten in 2009 were not in the list of the top ten in 2000.

Table 3 presents the share of the ten top machinery exports as a percentage of total exports and as a share of total machinery exports for selected years, 1980–2009.

5. The degree of Poland's machinery exports specialization

This section examines the degree of specialization in Poland's machinery exports and its changes over the period covered in this paper. The technique used is that presented and developed by the authors in a recent article [Kellman and Shachmurove 2011].

The Trade Specialization Index (TSI) used here and presented in the following figure is similar to the Herfindahl-Hirschman index (HHI) used by the U.S. Federal Trade Commission when determining the degree of market concentration in a group of industries, - see, for example, Peppall, Richards, and Norman [2008]. The higher the TSI index, the higher the degree of specialization [Kellman and Shachmurove 2011]. These measures are calculated using the relatively detailed, or disaggregated, data at the 4-digit SITC Rev 2. The HHI index is typically interpreted as a measure of competitiveness within an industry. Similarly, the TSI measure can be viewed as a measure of potential competitiveness of the international trade sector for a country.

The Specialization Index defines 'specialization' as coinciding with, or consisting of, the level of dispersion between the volumes exported. The higher the

Figure 22. Poland machinery exports specialization index
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

dispersion is, the higher the degree of specialization. As discussed in the article referenced above, the problem of identifying and measuring the degree of specialization in international trade is conceptually similar to the need for a sensible measure of market power in industrial organization. As noted, the Trade Specialization Index (TSI) is methodologically similar to the HHI index [Kellman and Shachmurove 2011].

It is clear that during the decade and a half following the collapse of the COMECON state-trading system from 1980 to 1995, there was a clear decrease in the degree of specialization in Polish exports. This was a period in which Poland's exports of relatively sophisticated machinery tended to decrease as a proportion of all commodity exports. Within the machinery product sector, one might have expected the opportunity to export to a relatively sophisticated West European market to have elicited a growing degree of specialization in those types and varieties in which Poland may have enjoyed a comparative advantage. In fact, this is not what happened. It seems that this period up to the mid 1990s was one in which the need to establish new and unfamiliar marketing channels brought forth a broadening of selection, both in types of machines and presumably variety of quality. This was also a period in which non-sophisticated commodity exports grew relatively rapidly. However, from 1994, when Poland officially was accepted as a member of the European Union, its machinery exports increasingly demonstrated a growing degree of specialization as it pursued a narrower band of specialization in which its comparative advantage has been revealed.

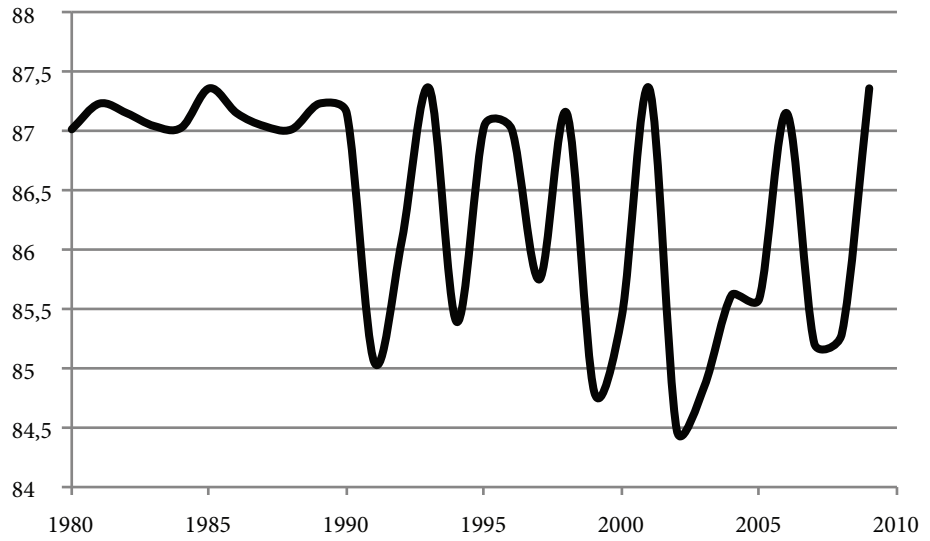

Figure 23. Sophistication Index
Source: Own calculations based on International Merchandise Trade Statistics, United Nations Statistics

6. Degree of sophistication of Poland's machinery exports

This section presents an index that was specifically designed to measure the level of sophistication of a country's export mix. Lall, Weiss and Zhang [2006] first presented and calculated this index in *The "Sophistication" of Exports: A New Trade Measure.* Each point in the following Figure 23 indicates a weighted average for each of the two Sophistication indices. The weights are Poland's export values, calculated at the 4-digit SITC Rev 2 level of aggregation. The indices refer to data aggregated up to the 3-digit level, as presented in Lall, Weiss and Zhang [2006]. To our knowledge, this is the first time the sophistication index has been used in an empirical examination of the characteristics of trade of any transitional economy.

Currently, comparative advantages are not typically associated with natural resource endowments. Rather, they are created by trade environments and policies. Thus, competitiveness is closely associated with the ability to maintain levels of sophistication in those products in which a country gains international market shares. Sala-i-Martin [2010, p. 9], in De Grauwe's Dimensions of Competitiveness [2010], explicitly cites level of sophistication as one of the key 'pillars of competitiveness.'

It seems clear from Figure 23, that during the first decade following 1980, there were relatively small changes in the measured sophistication of Poland's machinery exports. Then, during the 1990s, there seemed to be a tendency for a decrease

in this measure of sophistication. Next, from 1999 to 2009, the trend seems to be somewhat positive.

In order to obtain an objective indication of the trend, we estimate an Ordinary Least Squared (OLS) econometric trend for the entire period. The time trend coefficient shows a decreasing level of sophistication (at the 5% significance level). However, in the most recent period, from late 1999 to 2009, the coefficient is somewhat positive (significant at the 10% level).

Sophistication Index

The REG Procedure; Model: MODEL1 (1980–2009)
Dependent Variable: Sophistication Index
Number of Observations Read 30
Number of Observations Used 30

Analysis of Variance					
Source	**DF**	**Sum of squares**	**Mean square**	**F Value**	**Pr > F**
Model	1	7.09759	7.09759	9.68	0.0043
Error	28	20.52311	0.73297		
Corrected Total	29	27.62070			

Parameter Estimates					
Variable	**DF**	**Parameter estimate**	**Standard error**	**t Value**	**Pr > |t|**
Intercept	1	198.49903	36.01893	5.51	<.0001
year	1	–0.05620	0.01806	–3.11	0.0043

The REG Procedure; Model: MODEL2 (2001–2009)
Dependent Variable: Sophistication Index
Number of Observations Read 8
Number of Observations Used 8

Analysis of Variance					
Source	**DF**	**Sum of squares**	**Mean square**	**F Value**	**Pr > F**
Model	1	3.08120	3.08120	4.15	0.0877
Error	6	4.45004	0.74167		
Corrected Total	7	7.53124			

Parameter Estimates					
Variable	**DF**	**Parameter estimate**	**Standard error**	**t Value**	**Pr > |t|**
Intercept	1	–457.50280	266.50451	–1.72	0.1369
year	1	0.27085	0.13289	2.04	0.0877

Conclusions

This paper applies several mutually independent statistical tests to examine the hypothesis that Poland reacted to the major shift in its international economic environment flexibly, rapidly, and rationally. The results obtained from all five tests support the assumption that this transition was accomplished in a relatively short period of time despite the major disruptive changes called for by the nature of the new competitive challenges.

The first test, examining relatively aggregate (one-digit SITC) data documents the immediate impact during the 1980s. In this short period, Poland was able to shift away from a concentration in sophisticated and low-quality machines due to the fact that the Soviet system did not reward quality. While pre-1980 Poland fulfilled the needs of a Soviet Union that tended to focus on quality issues within a narrow military scope, it had the wrong 'mix' for the new consumer-directed market era. During the relatively short period, Poland managed to create a major change in its export composition, away from those relatively sophisticated sectors in which it suffered a clear comparative disadvantage vis-à-vis its new and increasingly dominant trade partners in Western Europe.

The same shift in compositional pattern was evidenced when the analysis focuses on detailed product groups at the four-digit SITC level of aggregation. Whereas the first part of the study noted a systematically decreasing weight of machines in all exports (an inter-sector perspective), the second takes an intra-sectoral point of view. This second stage of this paper examines the measure of product specialization **within** the machinery (SITC 7) product group. Note that this section focuses solely on exports of machinery (SITC 7). The finding is that in the 1980s Poland tended to specialize in fewer types of machinery. In other words, Poland was producing a larger variety of machines, and in this way was becoming less specialized within the machinery product export sector.

The third part of the study calculates the (Grubel) measure of intra-industry ('two-way') trade. Since this measure has been used in the literature as a measure of sophistication, and has typically been associated primarily with the exports of relatively rich and relatively sophisticated producers, we use this statistic as a proxy for product sophistication. Again, it is found that the relative weight of

intra-industry exports within the machinery exports of Poland tended to decline during the 1980s.

The fourth empirical test examines the top ten machinery product group t the fourth-digit SITC level of aggregations. In the period following Poland's joining the European Union, its exports demonstrated a rapid introduction of new machinery types. This was clearly a change from the stagnation of the 1980s where very little changes took place in Poland's machinery exports.

The fifth test applied the Lall, Weiss and Zhang 'Sophistication Index'. This index, has not, to our knowledge, applied to examine the shifts in sophistication of any given country, notably any transitional economy. This is the first such application of this new index in the literature. The Lall, Weiss and Zhang Index associates the degree of sophistication that attaches to any given exported product with the per-capita income associated with the country mix of the exports of any given exported product, at three and then again at the four-digit SITC levels of aggregation. We use the indices calculated for 1990 in Lall, Weiss and Zhang [2006]. In this case, the index we use had been designed to reflect the level of product sophistication. It is important to note that this Sophistication Index is not related functionally or conceptually to the measures we have used up to this point (e.g., with the Kellman–Shachmurove TSI index, or the Grubel IIT measure).

We obtain one value for the Sophistication Index (SI) for each year. This is the weighted average of the product specific values of SI calculated by Lall, Weiss and Zhang. These are in turn weighted by the specific composition of Poland's machinery exports for each year. Though the time pattern of the weighted SI are not as clear and obvious to the eye as those obtained from the other indices and measures in this paper, it is still valid that the pattern obtained from the other indices is, if weakly, supported by the time pattern for SI. In short, the levels of overall sophistication of the Polish machinery exports tend to decrease over the 1980s. This is consequently supported by an econometric estimation applying an OLS time trend model with the SI as the explained variable and the year as the independent variable. The results are found to be significant at the five- percent level.

In each of the five independent measurements of the degree of sophistication embodied in Polish machinery exports, there is a consistently observed, and explicitly estimated, positive time trend characterizing the period roughly from the point at which Poland joined the European Union to the last year of the sample, the year 2009. Finally, the results summarized in this chapter are found to reveal a clear capability to maintain international Competitiveness even during the recent major Global Crisis that affected all of Poland's major international markets.

Appendix

Why Focus on SITC 7?

We chose the subset entitled machinery and transport equipment, following the extensive work pioneered by Kravis and Lipsey [1982]. The products, which fall within SITC 7, include all machinery, transport equipment telecommunications equipment, and computer-related products. These would include all 'finished capital goods' (as defined in Vollrath and Johnston [1991]), which require intense use of skilled labor and of capital. These would also encompass most 'producer goods' (as defined by Richardson and Zhang 2001, p. 205). Finally, Kravis and Lipsey [1982] note in several places, that this group of products is especially important in international trade. This special or key importance of this product group – machinery (SITC 7) is widely followed and cited in the literature [Lipsey 1971; Kravis and Lipsey 1982]. Finally, whereas products falling in categories 0 through 6 tend to be raw-material intensive, and homogeneous; those in category 7 are not. This means that neither centralized commodity exchange pricing, nor fortuitous availability of raw materials (or the lack thereof) are likely to affect the levels or changes in revealed comparative advantage for these products. Hence, we may focus directly on 'Acquired' comparative advantage (rather than on 'Natural' comparative advantage), which is more likely to be affected by trade policy within the exporting country.

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