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Fakulta sociálních věd

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Bakalářská práce

2012 **Jakub Vondřička**

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Testing Heckscher-Ohlin model on case of the Czech Republic

Bakalářská práce

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Abstrakt

Práce testuje Heckscher-Ohlinův model na datech pro Českou republiku. Nejdříve uvádí teoretický základ teorie vybavenosti a popisuje vývoj české ekonomiky, na jejichž základě staví hypotézu o faktorové náročnosti českých exportů a importů. Tato hypotéza je následně otestována použitím input-output analýzy na datech z roku 2005. Práce se rovněž zabývá vysvětlením předpokladů Heckscher-Ohlinova modelu a input-output analýzy a jejich vlivu na výsledky empirického testu. Z výsledků práce vyplývá, že vztahy vyplývající z teorie Heckscher-Ohlinova modelu jsou v souladu s ekonomickou realitou ČR.

Abstract

The thesis tests the Heckscher-Ohlin model on the Czech Republic data. First, it presents theoretical background of the factor abundance theory and describes the development of the Czech economy. Based on these, it builds a hypothesis about the factor intensity of Czech exports and imports. The hypothesis is then tested using the input-output analysis on the data from the year 2005. The thesis also explains the assumptions of the Heckscher-Ohlin model and the input-output analysis and their impacts on the results of empirical test. Results of the thesis show that the relations predicted by the Heckscher-Ohlin model are in line with the economic reality of the Czech Republic.

Klíčová slova

teorie vybavenosti, mezinárodní obchod, input-output analýza, Heckscher-Ohlin model, testování

Keywords

factor abundance theory, international trade, input-output analysis, Heckscher-Ohlin model, testing

Rozsah práce: 75 546 znaků

Prohlášení

Prohlašuji, že jsem bakalářskou práci vypracoval samostatně, použil pouze uvedené prameny a literaturu a nevyužil práci k získání jiného nebo stejného titulu. Souhlasím s tím, aby práce byla zpřístupněna pro studijní a výzkumné účely.

V Praze dne 2. ledna 2012

Jakub Vondřička

Poděkování

Rád bych poděkoval vedoucímu mé práce, Ing. Mgr. Vilému Semerákovi PhD. za trpělivost, podporu a užitečné rady při psaní práce.

CONTENTS

1 INTRODUCTION

Empirical testing of the Factor Endowment Theory is a common topic of international-trade papers. Every paper uses a specific modification of Heckscher-Ohlin model. The specific models differ in a number of factors considered in the testing, number of countries involved in international trade (bilateral/multilateral trade models), the actual tested countries and other variations. Factor price equalization, existence of trade barriers and homogeneity of preferences across trading countries form the main variable assumptions of used models. The subject of testing is the fundamental hypothesis which is given by the subject of the work itself and it is present in all the works on the theme. We try to test that countries that accumulate a factor see their production and export structures shift towards industries that intensively use that factor. In my work, I stick to this hypothesis and try to test it on a specific case of the Czech Republic.

Diversity of the papers is given by specifications of used trade models and to some extent also by specifics of tested countries. The model itself is tied by several assumptions such as factor price equalization, existence of trade barriers and homogeneity of preferences across trading countries. By adjusting the model and loosening some of the assumptions we can get more accurate results and more precise description of the relationship between the factor proportions and exports. If we look at some more sophisticated models, as used for example by BRECHER, CHOUDHRI (1993) or CHOI, KRISHNA (2004) who dealt with the case where factor prices are not equal between countries, we can see that they brought much more favorable results than the basic models. In this paper I stick to the basic Heckscher-Ohlin model and try to find out how it will perform in case of small export oriented country such as the Czech Republic.

However, using standard Heckscher-Ohlin model doesn't allow me to disregard the cautious approach to the testing and building the hypothesis on the correct assumptions. I decided to use the input-output analysis introduced by Wassily Leontief to test the static relations predicted by the Heckscher-Ohlin model. For sake of simplicity, for formulating the hypothesis about the foreign trade of the Czech Republic, I use the model with assumption of factor price equalization and assumption of no technological differences across the trading countries.

To study the structure of factor proportions in different industries I use the data presented in form of symmetric input-output tables provided by Eurostat. Although the used data are not very recent, the dataset available for all the EU countries is very comprehensive. This allows me to measure factor proportions and get import and export statistics of every single industry.

In my work, subject of the testing is the Czech Republic. As a small, export-oriented country it provides clear picture of the export structure and its dependence on the factor accumulation without being affected by price distortions stemming from the exports shifting the global price of the exported good. Since majority of Czech exports go to Germany, Slovakia or other EU country I can concisely use the assumption of no trade barriers in the model.

1.1 Structure of the thesis

The thesis is divided into five chapters. First chapter is an introduction you are reading right now. It shows the objectives of the thesis, its structure and also reviews the literature on empirical testing of the factor abundance theory.

Second chapter gives an overview of the economy of the Czech Republic. It provides a brief analysis of competitiveness and openness of the Czech economy as well as description of its development, main trade partners and structure of foreign trade.

In the third chapter I present the theoretical basis and motivation for my empirical testing. I describe the mechanisms of Heckscher-Ohlin model and the most important theorems derived from it. Then I proceed to the explanation of assumptions of the Heckscher-Ohlin model and the confrontation of these assumptions with the real-world evidence.

Fourth chapter represents the core of my thesis. It provides the hypothesis for the empirical test, based on the theory presented in chapter three. Moreover, it describes the input-output analysis and the data used for the testing. Last section of chapter four describes the results of the input-output analysis.

Fifth and the final chapter focuses on confronting the results with the hypothesis presented in chapter four and summarizing the thesis.

1.2 Literature review

First attempt to test the Heckscher-Ohlin model was made by LEONTIEF (1953). In his work, Leontief used the data on the US economy from the year 1947. He used the input-output analysis to test the Heckscher-Ohlin theory and reached the results now known as the Leontief Paradox. He found that the United States imported goods that were 30% more capital-intensive than the goods exported by the US. These paradoxical findings led Leontief to proceed with another test. LEONTIEF (1956) repeated the test for US data from the year 1951. Once again, he found that US imports were more capital-intensive than US exports.

Further, I studied various literature dealing with the testing of Heckscher-Ohlin theory. Pretty straight-forward approach to the testing is presented by BOWEN, LEAMER, SVEIKAUSKAS (1987). Their work tests the relationships among industry input requirements, country resource supplies, and international trade in commodities using data on twelve resources, and the trade of twenty-seven countries in 1967. Their findings are rather surprising. They reject the Heckscher-Ohlin proposition that trade reveals relative factor abundance and tend to favor the weaker models that allow technological differences and measurement errors. Similar approach to the testing is used by OPP, SONNENSCHIEN, TOMBAZOS (2009) with focus on Rybczynski's Theorem. Results of their tests suggest that Rybczynski's classic comparative statics can be reversed in a Heckscher–Ohlin world when preferences in each country favor the exported commodity, possibly leading to immiserizing factor growth. Both these papers use the assumptions of factor price equalization in their models. Another test performed on The Republic of Korea was done by RAMAZANI, MASKUS (1993). Their test uses the multi-factor variation of the model. The test involves a comparison of independent measures of relative factor endowments with endowment rankings revealed by Korea's international trade and total factor intensities. The results strongly suggest that the revealed factor endowments departed significantly from actual factor supplies.

Other papers provide slight modifications to the basic model such as BRECHER, CHOUDHRI (1993). His model deals with the case where factor prices are not equal between countries. Brecher and Choudhri run their tests on the data for Canada and the United States. They introduce three variants of the model and finds that his results support the Heckscher-Ohlin model of production. One of the variants, that allow imperfect factor mobility within each country, shows especially favorable results. Another test dealing with the case where factor prices are not equal between countries was done by CHOI, KRISHNA (2004). Their paper uses OECD production and trade data to test the restrictions on the factor content of trade flows that hold even in the absence of any assumptions regarding consumer preferences. In a further contrast with other papers, their tests concern only bilateral trade flows that are supposed to be backed by higher quality data then the more commonly used multilateral trade models. Test by ROMALIS (2004) implements Paul R. Krugman's (1980) model of monopolistic competition and transport costs in the model. Romalis is using a multi-country version of the Heckscher-Ohlin model and assumes that the commodity structure of production and bilateral trade is fully determined. Results of his test correspond with the hypothesis that countries that rapidly accumulate a factor see their production and export structures systematically shift towards industries that intensively use that factor. HARRIGAN, ZAKRAJŠEK (2000) implement estimation of immeasurable technological differences into their model. In addition to the main factor abundance hypothesis they also consider an alternative hypothesis that the level of aggregate productivity by itself can explain specialization. Results of their tests support the hypotheses and show the importance of factor endowments on specialization.

Some papers test additional theories related to the factor abundance, which influence the approach to the testing. CHE (2010) divides her paper in two parts. First part consists of testing of factor abundance theory and the second part follows to explore the linkage between structural coherence and economic growth. This approach somehow exceeds the sole testing of the factor abundance theory present in all the previously mentioned papers. On the other hand, the factor-abundance-testing part itself is less detailed than in the papers aimed specifically on that kind of testing. VENABLES, LIMAO (1999) focus on the geographical dimension of the trade. Besides the factor endowments and factor intensities, their model involves distance of trading countries and the transport intensities of different goods.

In the end, we look at two papers by Zhang, Wang and Yan. ZHANG, WANG, YAN (2010a) present an alternative approach to testing of factor abundance theory using Heckscher-Ohlin model. Their tests on the Chinese industrial data and U.S. import markets abandon the methods of estimating and comparing product factor contents of imports and exports (or net exports) based on the input-output tables. Instead, they focus on the industry factor intensity and its relationship to the export capability of the industry based on their restatement of the Heckscher-Ohlin Theorem. Their regression models use additional proxies for industry factor intensity, industry competition intensity, average firm scale, and industry export capability. Results of the tests strongly support the main hypothesis of Factor Abundance Theory. ZHANG, WANG, YAN (2010b) extend the empirical tests of Factor Abundance Theory to the European Union import markets. Using the same approach as in their previous tests on U.S. import markets, authors provide further evidence that support their previous findings and compare the results of both tests.

2 ANALYSIS OF INTERNATIONAL TRADE ENVIRONMENT OF THE CZECH REPUBLIC

2.1 General characterization of the Czech Republic economy

2.1.1 Analysis of the competitiveness of the Czech Republic economy

Czech Republic is relatively small economy with characteristically small geographical size. Due to its size, Czech Republic disposes of rather incomplex resource base. Climatic conditions limit agricultural production. Relatively small population is limiting factor for size of internal market and amount of domestic workforce. Location of the country in centre of Europe makes relative advantage due to amount of international transit of goods and services going through the country. Another comparative advantage is given by economic factors namely relatively stable social environment, relatively high level of industrialization, relatively low levels of wages and qualified labor force with high degree of education. Insufficient adaptability of home economic subjects and economic environment as a whole makes one of the crucial comparative disadvantages of the Czech Republic. Spillovers of the communist era made for lack of home capital and insufficient knowledge of foreign languages. Present disadvantages include ineffective justice, problematic enforcement of law and high rate of corruption.

Comparative advantages of the Czech Republic

- advantageous location in Central Europe => transit country
- convenient transport connections
- high education => skilled workforce
- relatively low wages and salaries
- diverse natural structure - development of tourism

Comparative disadvantages of the Czech Republic

- small size and small amount of mineral resources
- temperate climate, which greatly affects agricultural production
- environmental pollution of nature

- small population (in terms of limiting the size of the internal market and the labor force)
- low competitiveness of products abroad

In comparison with other countries that underwent transformation, public administration and institutions shows greater security and stability, but in comparison with other EU countries, the quality of public administration in the Czech Republic is at a lower level than in the majority of Member States. Misuse of public funds is frequent and the extent and level of corruption and non-transparent procurement is much higher than in most EU countries. The Czech Republic also lacks enforcement of accountability of public authorities and has worse law enforcement in general, including excessive length of judicial proceedings. Geographical location of the CR and the density of transport networks determine its transit role. The Czech Republic has one of the densest rail networks in Europe and in the world, but it doesn't have enough high-quality high-speed rail corridors and it isn't connected to other rail routes in Europe. In comparison with developed European countries, Czech Republic lacks the quality interconnected highway network. The capacity of waterways is sufficient, but its parameters do not meet the requirements of the internationally important waterways. Another weakness of the CR infrastructure is uneven coverage by data services throughout the state and the limited availability of high-speed data services. The Czech Republic also has a very stable banking sector. The advantage is the independence of the Czech National Bank's monetary policy. On the other hand, there is imminent risk of exchange rate, which has a bad impact on the ability of exporters to plan in the longer term. Furthermore, there are other disadvantageous factors such as the high cost of currency hedging transactions and other transaction costs of companies. Compared to other EU countries, proportion of the population with secondary or better education is high. On the other hand, mobility of labor is very low, which is caused by inflexible housing market and unwillingness of the population to move for work.

According to comparative advantage, imports of the Czech Republic are formed mainly by agricultural products, fuels and raw materials for industrial production, as well as machines and advanced technology. Main items of exports are machinery and transport equipment, semi-finished industrial and consumer goods. Great export potential is also created by services, especially tourism. Services however, are harder to quantify and thus it is likely that the export data will be somewhat distorted in this regard. It is possible that the export of services will be underestimated.

2.1.2 Economic openness of the Czech Republic

Economic theory defines two extreme cases of openness - open and closed economy. Both types of economies differ in their degree of openness to the rest of the world and in degree of their engagement in international trade activities. Open economy is involved in international trade with other countries, therefore part of its production is exported and consumed abroad while part of home income is used to purchase foreign production and import goods from abroad. On the other hand, in case of closed economy country is not participating in international trade and all its production is consumed within the country. This means that the country has to be fully self-sufficient and produce everything that its residents consume i.e. amounts of produced and consumed goods are equal. Openness of real-world economies ranges between these two extreme cases.

Most commonly used indices of openness of national economies are:

- Foreign trade turn-over (export+import)/GDP
- Export/GDP (at given common prices)
- Import/GDP (at given common prices)
- Export, import/aggregate demand (total home AD)

Degree of openness of the economy expresses the rate of engagement of the economy in international trade. It is most often expressed by indices of export or import to GDP ratio. World Bank data show that larger economies tend to be less open and engaged in international trade. There is also a positive correlation between economic development of a country and its degree of involvement in international trade i.e. the more developed country given comparable economic size the more intensively it engages in international trade compared to a less developed country. Openness of economy depends on many factors such as geographic position of a country, political organization, present natural resources or size of the economy. If we consider an economy that is close to closed economy situation, then it is most likely a big country with large home market and with high endowment of natural resources. On the other hand, for open economies, it is typical to be small and dependent on imports of resources and technologies from other countries. Openness of economy brings variety of advantages and disadvantages. Advantages include comparative advantage arising from international trade, increase in effective allocation of production factors and their growing productivity, increasing size of the market and foreign demand, imports of new products and technologies and higher consumption possibilities. Disadvantages of open economy, on the other hand, include dependence on business cycle of main trade partners, possible import of inflation from trade partners with higher growth of price level and decreasing autonomy of economic policies.

Czech Republic is a small open economy with typically high degree of economic openness towards other countries i.e. intensive international trade. Given its size, Czech Republic can't influence its trade partners and it is forced to accept rules of given economic system. Degree of openness of the Czech Republic given as a rate of foreign trade of goods and services to GDP is high compared to other similarly large EU economies.

Since 1990, economy of the Czech Republic went through so called transformation. Reaching present level of liberalization of international trade can be appointed as a success of the transformation process. Openness of the economy means that the country is involved in international trade at many dimensions, movement of goods, labor and capital in particular. Integration in international trade brings increased wealth and increase in consumption and standard of living in small open economies.

Typical characteristics of open economies:

- Movement of capital to areas with higher efficiency of utilization of other less mobile factors of production (labor). Enterprises receiving FDI are vital for competitiveness of the economy as they produce majority of exported goods.
- Migration of population, including emigration (moving to a foreign country) and immigration (increase in population due to people moving from foreign countries). In hypothetical case of ideal economy, immigrants present

temporary burden as they enter the market but in the long run they create new labor possibilities and increase economic growth.

2.2 Development of the Czech Republic foreign trade in years 1993 – 2010[1]

Absolute volume of the Czech foreign trade amounted to 847 685 mil. in 1993, and in 2002 this indicator reached a total value of 2 580 111 mil. We can see a gradual increase in proportion of exports over imports in the total foreign trade turnover in this period. In 2002, coverage of imports by exports reached a total of 94.6%, which was the highest value since 1993. In 2003 this ratio remained unchanged. During the 1993-2002 decade, Czech exporters reoriented primarily to the markets of European Union countries and relatively quickly and significantly abandoned the territory of Russia and the markets of developing countries. During this period, up to one third of exports to these countries disappeared, as the proportion of the total Czech exports to these countries fell from 32.6% to 20.8%. As a result, the share of exports to countries with developed market economies increased to a total of three quarters of Czech exports. Germany played a key role in the trade as a neighboring market with more than 90 million consumers. Germany represents an EU country with which the Czech Republic has the highest trade surplus.

Commodity structure of Czech exports undergone a significant change in this period as well. Export of Czech engineering increased fivefold in that decade (from 122 631 mil in 1993 to 623 009 mil in 2002). Export of road vehicles recorded the most significant increase (in particular Skoda); other growing segments included office machines and automatic data processing machines, electrical devices and industrial equipment. In 2002, more than 60% of Czech foreign trade was carried out in Euros (68% of exports and 64% of import).

The growth rate of the Czech economy after year 2000 and further development in the coming years was conditional to some specific aspects related to the nature and

[1] Source for all the data in this section are statistical yearbooks of the Czech statistical office, found online at www.czso.cz.

focus of economic policy of the Czech Republic. Economic Policy of the Czech government in the nineties focused on macroeconomic stabilization. Upcoming period brought acceleration of economic difficulties (decreasing GDP growth rate, a rapid increase in trade deficit, growing unemployment, etc.). As a result, various measures began to be developed including state restructuring programs, retraining of workers, pro-export policy, and protection of domestic market from foreign competition (the Anti-Dumping Act). Measures implemented in this period are often called industrial or structural policy in developed countries. Since 1998, investment incentives for domestic and foreign investment became an important part of industrial policy. These investment incentives made a decisive initial impulse for growth of individual components of GDP in terms of macroeconomic expenditure, income and product. In connection with the incentives, government expenditures on goods and services for infrastructure development increased as well. Government and foreign investment stimulated growth in domestic investment. Rising number of work-posts led to a decreasing unemployment rate, growing macroeconomic income, corporate profits, disposable income and total household consumption. With a certain delay but with the multiplier effect, domestic and foreign investment promoted growth in the final product and even in the production of goods and services for foreign entities. During individual years of this period, impact of household consumption, gross private domestic investment, government spending and net exports on GDP and its growth rate changes.

Between 2000 and 2005, trade balance was more favorable at current prices than in the physical volume. The terms of trade were still positive, the highest value reached in 2004. Price effect had a positive influence on trade balance, but so did the evolution of foreign trade. During the years 2000 to 2005 the trade balance at current prices was still improving. However, at constant prices, trade balance deteriorated since 2004 or it had a less distinct positive development (year 2002). In 2005, however, year on year trade balance has improved by CZK 95 billion at constant prices, which was nearly CZK 30 billion more than in foreign trade at current prices. This development was the result of substantial supply-side changes and very unfavorable price developments in the group of fuels. Between 2000 and 2004, the contribution of price effects to the annual change in trade balance was strongly positive. In 2005, however, it was significantly negative. European countries participated at the improvement in the territorial structure of the Czech foreign trade from 2004 to 2005 by 32 billion CZK, America 19 billion CZK, Asia 11 billion CZK and the rest of the world 5 billion CZK. Trade turnover with EU countries reached 86.7% of the total foreign trade turnover. The predominance of growth of exports over imports was evident in all commodity groups except fuel. From 2004 to 2005, the proportion of engineering and transport equipment in the commodity structure of exports has increased to 51%. Production of automotive industries contributed to the increase by approximately 80 billion CZK, other contributing sectors included electronics, computers and industrial machinery. Export of automotive products also increased due to the launch of new production capacities TPCA (Toyota, Peugeot, Citroën Automobile) in Kolín. Imports (in current prices) for investment needs did not reach the 2004 level, due to lower domestic demand for imports of industrial machinery. Increasing completion imports were directed mainly into the automotive industry, as well as into programs for infrastructure development of highways, expressways and airports (e.g. Construction of terminal North 2 at the Prague airport Ruzyně). Imports, which accounted for use in production, accounted for half of total imports of goods. Annual increase of production goods was influenced by growing demand of the manufacturing industry, together with rising prices of imported energy commodities, mainly oil and natural gas. Increase of imports of non-energy raw materials – copper, zinc, silver, lead, aluminum, whose prices on the world market had been rising – reflected demand in metal processing industry.

Just before the Czech Republic joined the European Union and shortly after that, foreign trade was affected by a number of administrative and economic factors related to participation in the enlarged European Union market. Joining the European Union led to permanent changes in foreign trade or to changes with different intensity of long-term influence. Even before accession to the European Union, tariffs vis EU were eliminated, which substantially improved conditions for trade with EU member states. On top of that, after the accession, new tariffs towards non-EU countries were applied which deepened the foreign trade with the EU countries even further. Goods of non-European origin were hampered by higher tariffs or EU anti-dumping measures but on the other hand, the common foreign trade policy towards non-EU countries has opened new possibilities for Foreign Trade. At the same time, many agreements that the Czech Republic had concluded with some states in the previous period terminated. The above stated factors had also brought a growth in foreign direct investment inflows, which used the following benefits offered by the Czech Republic:

- Highly qualified workforce.
- Low production costs.
- Lower level of wages for skilled labor.
- A long-lasting country‘s industrial tradition.
- Advantageous geographical position for transit of goods being a Central European country.

Exports to the new EU member states showed highly above-average dynamics. The absolute increase in exports to the EU25 states was caused by higher exports to Germany, then to Slovakia, Poland, Hungary, Austria, the Netherlands, Belgium, France and Italy. Exports to other developed market economies (especially Japan and Canada) showed above-average growth rate as well, while exports to Russia and China were below average. In 2005, for the first time since creation of the Czech Republic, its foreign trade balance ended in surplus. In 2006, trade surplus was a double-digit value (in bn. CZK), which was caused by promoting trade with countries with which the trade balance had been passive in the previous period (France and Italy, the United States and Japan). In 2007, trade surplus with EU27 states significantly offset the deficit of trade balance with countries outside the EU27 (especially with China, Japan and Russia). Trade balance had been supported by the growth of production in manufacturing. The most important item of manufacturing exports was road vehicles, mainly cars and parts and accessories for motor vehicles.

Development of the German economy was crucial for the Czech foreign trade, because in 2007, Germany absorbed 31.0% of Czech exports. Fast economic growth of Slovakia, which was the second largest export orientation of the Czech Republic, in 2007, also helped to increase Czech exports.

In 2008, foreign trade turnover recorded decline for the first time since the Czech Republic joined the European Union and for the second time in the history of the Czech Republic. In 2009, Czech Republic's foreign trade saw the first significant drop in history. Compared to 2007, foreign trade turnover in 2008 decreased due to decline in annual exports, as imports almost stagnated at the 2007 level and in 2009 imports declined as well. The biggest decrease occurred in the 4th quarter of 2008.

Between 2008 and 2009, there was a significant decline in industrial production, which affected almost all manufacturing industries especially the production of vehicles. Weak foreign demand, induced by the global financial and economic crisis, had a negative impact on foreign trade of the Czech Republic. The negative effect of a decrease in exports had been mainly caused by the decline of German economy (by a record 5% in 2009), which is the most important export market for Czech companies and largely determines the development of Czech exports. Primarily in the 2009, domestic demand induced decline in imports of industrial consumer goods and a number of engineering items.

Due to appreciation of CZK against EUR and particularly against USD, exports and imports in those currencies recorded year on year growth in 2008. In 2009, the terms of trade development was positive and had a positive impact on external trade balance at current prices. The impact of prices on the trade surplus at current prices for year 2009 is estimated at CZK 57 billion.

If we analyze territorial structure of foreign trade we can see that trade surplus with EU27 states increased by CZK 71.1 billion. On the other hand, trade deficit with non-EU27 countries grew by CZK 89.6 billion. If we look more deeply at the territorial structure of the trade, we see that trade surplus with European transition economies fell by CZK 3.3 billion and the surplus with EFTA States declined by CZK 8.2 billion. Trade deficit deepened to CIS by CZK 38.9 billion, trade deficit with Other states increased by CZK 26.8 billion, deficit with other developed market economies increased by CZK 5.3 billion, deficit with developing economies grew by CZK 9.1 billion.

In 2010, exports increased by 17.7% (379.6 billion) and reached CZK 2 518.2 billion, compared to 2009. Imports increased by 20.3% (CZK 404.6 billion) and reached CZK 2 393.6 billion. The foreign trade in 2010 was influenced by the growth of industrial production especially in manufacturing industries, which was reflected in the growth of exports of manufactured goods and strengthening of its position in total exports in 2009. The main export groups of manufactured goods were machinery and transport equipment, namely road vehicles, electrical machinery, apparatus and appliances, computer equipment, devices and equipment generally used in industry and telecommunications equipment.

Development of terms of trade was negative in 2010. From January to November 2010 compared to same period of 2009, average export prices fell by 1.3% and import prices rose by 1.6%. The terms of trade reached negative values, and thus had a negative impact on external trade balance at current prices.

2.3 Trade structure in the year 2005

Since the input-output analysis presented in chapter four uses the data for year 2005, I present additional summary of Czech foreign trade for year 2005. I focus on the factors important to formulating the hypothesis for the empyrical test, which include the structure of the trade by commodity group and the structure of the trade by trade partner.

Foreign trade turnover for the year 2005 reached CZK 3 701 bn. Goods with higher added value i.e. moderately and highly complex mechanical and electrical products, along with other final products, achieved share of 63.0% of total exports and 56.9% of total Czech imports. Commodity items belonging to the High Technology Products formed 12.6% of total exports and 14.9% of total imports. Structure of the trade by SITC commodity group is shown in the Table 2-1.

Table 2-1 *Czech foreign trade by product, 2005*

	Commodity group (SITC)	Exports	%	Imports	%
0	Food and live animals	60412	3.2%	80962	4.4%
1	Beverages and tobacco	10664	0.6%	11683	0.6%
2	Crude materials, inedible, except fuels	46729	2.5%	50135	2.7%
3	Mineral fuels, lubricants and related materials	57189	3.1%	169588	9.3%
4	Animal and vegetable oils, fats and waxes	1749	0.1%	3616	0.2%
5	Chemicals and related products	117752	6.3%	203333	11.1%
6	Manufactured goods classified chiefly by material	406354	21.7%	371802	20.3%
7	Machinery and transport equipment	959106	51.2%	740637	40.5%
8	Miscellaneous manufactured articles	210990	11.3%	196846	10.8%
9	Commodities and transactions not classified elsewhere in SITC	494	0.0%	959	0.1%
	TOTAL	1871439	100.0%	1829561	100.0%

Exports for the year 2005 recorded an annual increase to all major groups of countries except for unspecified Global. In comparison with 2004, imports increased from all major groups of countries except for developing countries. Summary of foreign trade according to the trade partner is shown in Table 2-2.

Table 2-2 *Czech foreign trade by trade partner, 2005*

Group of countries	Exports	%	Imports	%
Developed countries	1691244	90.4%	1470480	80.4%
out of that: EU	1576322	84.2%	1295145	70.8%
other countries	114922	6.1%	175335	9.6%
Developing countries	66432	3.5%	104829	5.7%
Transitive European countries	45907	2.5%	14551	0.8%
Commonwealth of Independent States	58518	3.1%	140453	7.7%
Other countries[2]	8067	0.4%	97138	5.3%
Not specified	1271	0.1%	2110	0.1%
TOTAL	1871439	100.0%	1829561	100.0%

[2] China, North Korea, Cuba, Laos, Mongolia, Vietnam

3 THEORETICAL FRAMEWORK

3.1 The Heckscher-Ohlin model

The Heckscher-Ohlin theory of comparative advantage is one of the most influential theories in international economics. It extends the Ricardian theory, which assumes that comparative advantage stems only from differences in labor productivity, and involves differences in countries' resources in describing the creation of international trade.

First of all we should define what we mean by the *comparative advantage*. Trade of goods between the countries reflects differences in structure of costs of production. Goods that are relatively cheaper to produce at home are to be exported while other goods, that are relatively cheaper to produce abroad, are to be imported. The capacity that allows one country to produce at relatively lower price, giving opportunity to export, is called comparative advantage.

The Heckscher-Ohlin approach, also known as the factor-endowments approach is based on two expectations. (1) Goods differ in composition of factors needed in their production. Therefore, we can describe the goods according to their *factor intensity*. (2) Countries differ in their factor endowments and we can compare the countries according to their *factor abundance*. These two expectations lead to the essential hypothesis of the Heckscher-Ohlin theory that a factor-abundant country will specialize in production of goods that intensively use the given factor in their production. In other words, countries should shift their production towards industries that intensively use the relatively abundant factor.

The basic Heckscher-Ohlin model describes a simplified situation where only two countries, two goods and two factors of production are involved. Country's production constraint, the PPF curve, is given by the amount of labor and capital accumulated in the country. Intersection of labor and capital constraint curves shows us the point where the country is using all its labor and all its capital, so called *full-employment output point*. Relative prices of both produced goods in full-employment output point are given exogenously by demand represented by indifference curve. The exact relative price of both goods is equal to the slope of that indifference curve.

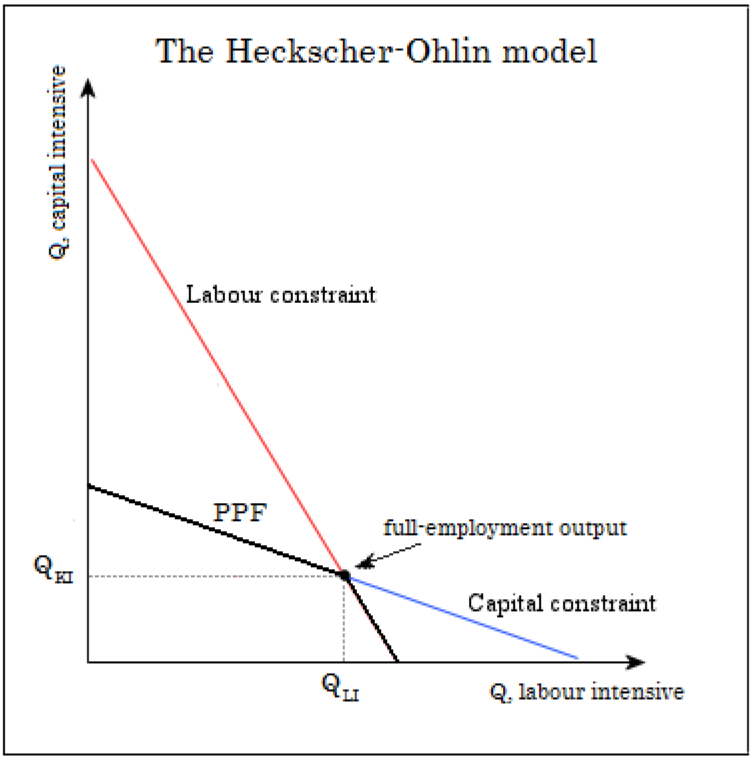

Fig.3-1 In the simple Heckscher-Ohlin model, PPF is given by labor and capital constraint curves. Intersection of the curves is the full-employment output point.

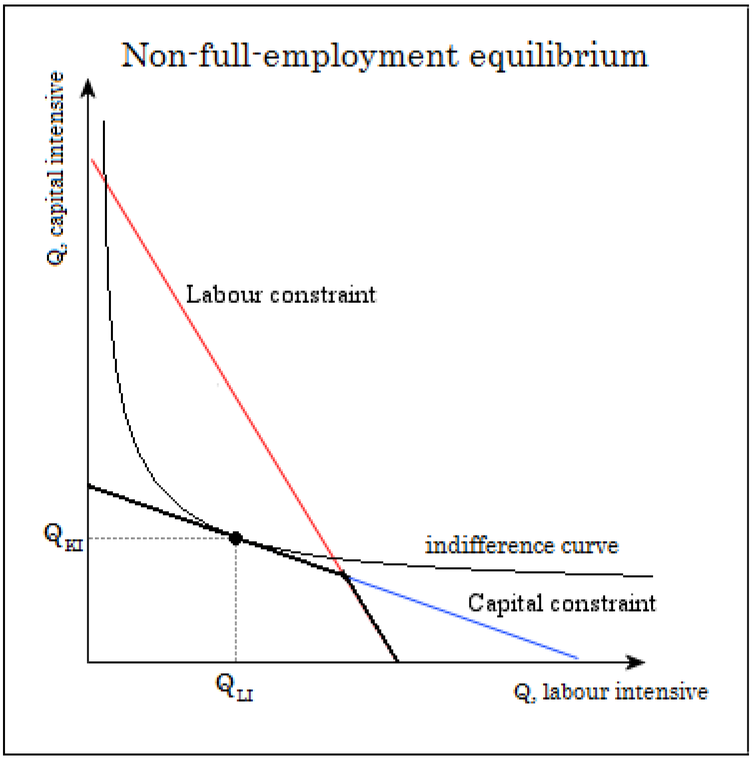

Fig.3-2 Notice that in some cases in closed economy situation, country doesn't have to be in full-employment output point in the equilibrium situation, given specific demand of consumers.

Let us now derive the exact formulas of simple Heckscher-Ohlin model. We consider two industries where α denotes the amount of labor needed to produce one unit of output and β denotes the amount of capital needed to produce one unit of output. So the amounts employed are

$$L_1 = \alpha_1 x_1 \tag{3-1}$$

$$L_2 = \alpha_2 x_2 \tag{3-2}$$

$$K_1 = \beta_1 x_1 \tag{3-3}$$

$$K_2 = \beta_2 x_2 \tag{3-4}$$

When the country has fixed amounts of labor $\overline{L}$ and capital $\overline{K}$ at its disposal, and they are fully employed, we get

$$\overline{L} = L_1 + L_2 = \alpha_1 x_1 + \alpha_2 x_2 \tag{3-5}$$

$$\overline{K} = K_1 + K_2 = \beta_1 x_1 + \beta_2 x_2 \tag{3-6}$$

To obtain the labor and capital constraints we solve equations (3-5), (3-6) for x_2:

$$x_2 = \frac{\overline{L}}{\alpha_2} - \left(\frac{\alpha_1}{\alpha_2}\right) x_1 \tag{3-7}$$

$$x_2 = \frac{\overline{K}}{\beta_2} - \left(\frac{\beta_1}{\beta_2}\right) x_1 \tag{3-8}$$

If we solve both equations (3-5), (3-6) simultaneously, we get the full-employment outputs of x_1 and x_2:

$$x_1 = \frac{\beta_2 \overline{L} - \alpha_2 \overline{K}}{\alpha_1 \beta_2 - \alpha_2 \beta_1} \tag{3-9}$$

$$x_2 = \frac{\alpha_1 \overline{K} - \beta_1 \overline{L}}{\alpha_1 \beta_2 - \alpha_2 \beta_1} \tag{3-10}$$

We can see that increase in supply of one factor shifts the PPF such that full-employment output point moves towards given factor-intensive good, rising production of that good and lowering production of the other. This predicted effect of Heckscher-Ohlin theory is called Rybczinski Theorem.

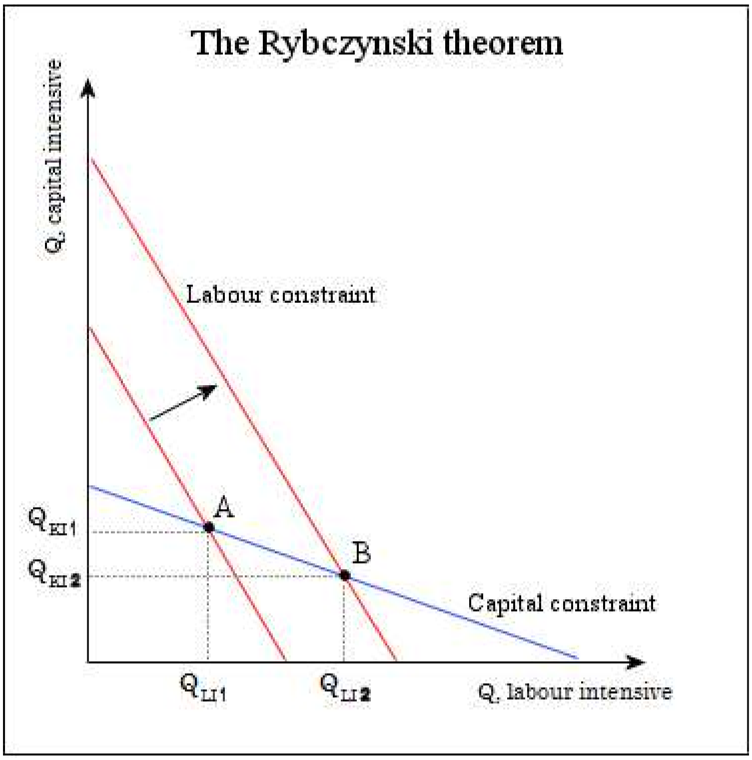

Fig.3-3 Increase in supply of one factor leads to a higher production in the industry that intensively uses that factor and lowers the production in the other industry.

We can also derive the Rybczynski theorem algebraically. We begin by looking at the equations (3-7), (3-8). Since we assume that $(\alpha_1/\alpha_2) \succ (\beta_1/\beta_2)$ i.e. Labor constraint curve is steeper than Capital constraint curve (industry x_1 is more labor intensive), we can rewrite this inequality as follows:

$$\frac{\beta_2}{\alpha_2} \succ \frac{\beta_1}{\alpha_1} \tag{3-11}$$

Now if we look at the equations (3-9), (3-10) we can see, that the denominator of the fractions is positive and therefore increase in $\overline{L}$ leads to higher output in the labor intensive industry (x_1) and on the contrary lowers the output of capital intensive industry (x_2). Analogically we can prove the same for capital, i.e. increase in $\overline{K}$ leads to increase in x_2 and decrease in x_1. This proves the Rybczynski theorem.

Next step in building the Heckscher-Ohlin theory is adding effect of prices into the model. The assumption of perfect competition ensures that profits in all industries are driven to zero, therefore allowing us to arrive with the following equations:

$$P_{Li} = a_{LLi}w + a_{KLi}r \tag{3-12}$$

$$P_{Ki} = a_{LKi}w + a_{KKi}r \tag{3-13}$$

where P_{Li} and P_{Ki} are the prices of labor intensive good and capital intensive good, respectively, w is the wage paid to labor, and r is the rental rate on capital. $a_{LLi}w$ is the payment to workers per unit of labor intensive good produced, while $a_{KLi}r$ is the payment to capital owners per unit of labor intensive good produced.

Similarly to deriving the PPF, we can now plot zero-profit conditions based on the given amounts of wages and rentals on capital. Intersection of the two zero-profit lines – the flatter line representing the capital intensive industry and the steeper line representing the labor intensive industry – marks the only wage-rental combination that can simultaneously support zero profit in both industries. This point represents the equilibrium wage and rental rates that would arise in an H-O model when the price of capital intensive good is P_{Ki} and the price of labor intensive good is P_{Li}.

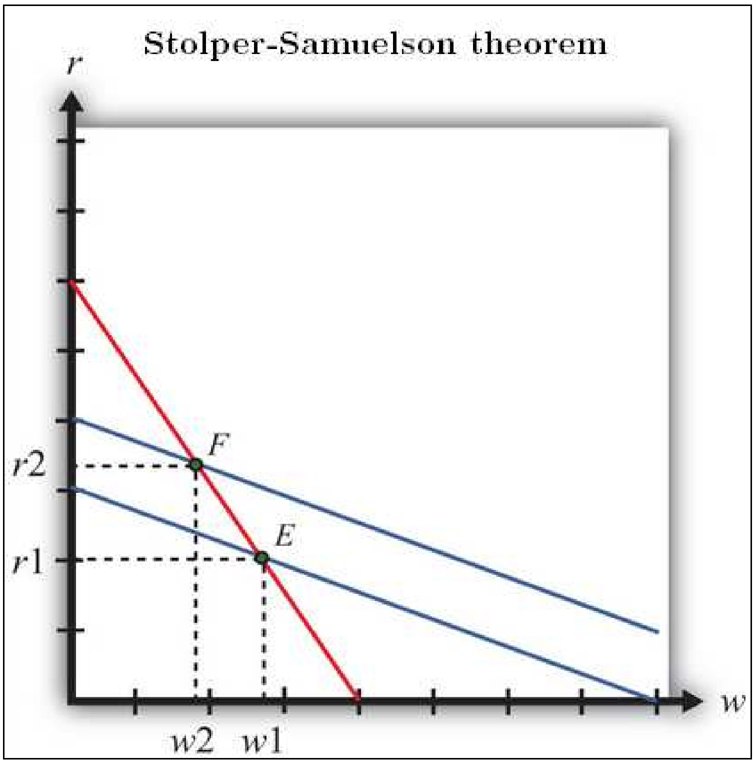

Fig. 3-4 When the price of capital intensive good rises, rent payed to the capital owners rises, while the wage falls. Source: online textbook International Trade: Theory and Policy

Now we look at the change in price of one good. Let's suppose that there is an increase in the price of one of the goods. If the price of capital intensive good rises, the equilibrium point shifts from E to F, causing an increase in the equilibrium rental rate from r_1 to r_2 and a decrease in the equilibrium wage from w_1 to w_2. Zero profit can be maintained in both industries at the new set of prices, but only with a higher rental rate and a lower wage. Thus, an increase in the price of a good will cause an increase in the price of the factor used intensively in that industry and a decrease in the price of the other factor. We call this effect the Stolper-Samuelson theorem.

With introduction of prices of goods and prices of production factors (w and r) we can modify the PPF with respect to the prices of production factors. The production possibility frontier can be derived such that the unit factor requirements are functions of the wage-rental ratio (w/r). This implies that the capital-labor ratios in each industry are also functions of the wage-rental ratio. This reflects the fact that firms would respond to the change in prices of production factors by reducing their demand for the factor that becomes more expensive and raising their demand for the cheapening factor. This adjustment will allow the firm to maintain minimum production costs and thus the highest profit possible.

Modifying PPF by introducing variable proportions change the shape of the economy's PPF. The labor and capital constraints with full employment can be written as

$$L = a_{LLi}(w/r)Q_{Li} + a_{LKi}(w/r)Q_{Ki} \quad (3\text{-}14)$$

$$K = a_{KLi}(w/r)Q_{Li} + a_{KKi}(w/r)Q_{Ki} \quad (3\text{-}15)$$

where a_{LLi}, a_{KLi}, a_{KLi} and a_{KKi} are functions of (w/r). Q_{Li} and Q_{Ki}, marked as Q_C resp. Q_S at the figure below, represent quantities of labor intensive good and capital intensive good respectively.

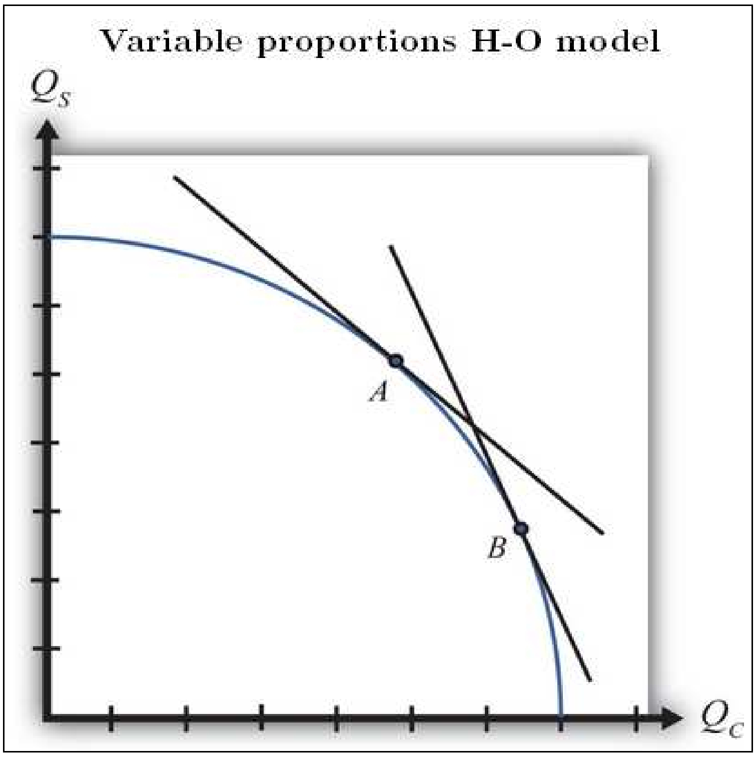

Fig.3-5 Slope of the PPF with variable proportions reflects increasing opportunity cost, since it represents the quantity of steel that must be given up to produce another unit of clothing. As we move from point A to point B, relative price of clothing against steel rises. Source: online textbook International Trade: Theory and Policy

Until now, we have talked about a single closed economy in a H-O environment. Before we close this theoretical chapter about the model, it would be appropriate to show how countries behave after promotion of free trade in the H-O environment. In a variable proportions Heckscher-Ohlin model, country's combination of goods produced in full employment output equilibrium is given by intersection of the PPF curve and the highest possible indifference curve. Now, since we assume that the countries (in the Figure 6 we chose United States and France) have identical technologies, they have the same production functions available to produce capital intensive goods (steel) and labor intensive goods (clothing). We also assume that the preferences are the same across countries; therefore the indifference curves are the same for both countries. The only difference that exists between the two countries in the model is a difference in resource endowments which is reflected in a different shape of the PPF curves. Country that is relatively more capital abundant will have their PPF shifted towards the capital intensive industry while the labor abundant country's PPF will shift towards the labor intensive industry.

Now if we introduce free trade, countries will specialize since then they can benefit from trading with the other country. Country that is capital abundant will export the capital intensive good and the country that is labor abundant will export the labor intensive good. We call this effect the Heckscher-Ohlin theorem. In a closed economy, countries would have to 'sacrifice' part of their specialization to satisfy consumer preferences. In a free trade setting, countries can produce the good that is relatively cheaper and export it; in exchange they import the other good which is produced relatively cheaply abroad. By trading, both countries reach higher indifference curve than they would have in autarky, increasing utility.

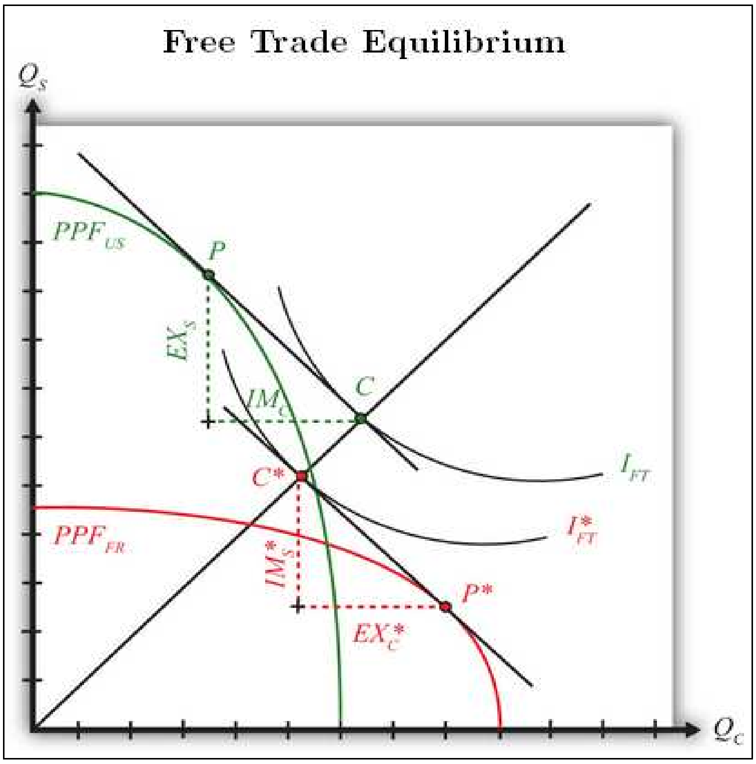

Fig.3-6 By promoting free trade, countries increase their utility by reaching higher indifference curves than they would normally have in autarky. Source: online textbook International Trade: Theory and Policy

Figure 3-6 shows us the benefits of free trade in the Heckscher-Ohlin model. We have a more capital abundant country (US) and a more labor abundant country (FR). Consumer preferences in both countries are the same, thus the same indifference curves apply for both countries. When we let the countries trade freely, instead of finding the equilibrium full employment production (and consumption) as intersection of PPF and the highest possible indifference curve, we can see that the countries produce in points P and P^* respectively and trading part of their production. To find the equilibrium, we need to lead a tangent to the highest possible indifference curve such that it is also a tangent to the PPF curve and the slope of the tangents is the same for both countries. By doing this, we get equilibrium production as well as consumption points C resp. C^*. We can see the amounts of goods traded between the countries as $EX_S = IM_S^*$: amount of capital intensive goods exported by the US and imported by the FR and $EX_C^* = IM_C$: amount of labor intensive goods exported by FR and imported by the US.

3.2 Assumptions of the model and confrontation with real-world evidence

While in the theory we clearly see that countries specialize according to their factor endowment to promote effective allocation of resources and benefit from mutual trade, some empirical studies provide evidence of the opposite. OPP, SONNENSCHIEN, TOMBAZOS (2009) focus their work on Rybczynski Theorem. Results of their tests suggest that Rybczynski's classic comparative statics can be reversed in a Heckscher–Ohlin world when preferences in each country favor the exported commodity, possibly leading to immiserizing factor growth. Plain empirical test performed on The Republic of Korea was done by RAMAZANI, MASKUS (1993). Once again, their test shows that revealed factor endowments depart significantly from the actual factor supplies. Their test uses the multi-factor variation of the model with the assumption of factor price equalization across the trading countries and focuses only on a very short time period of one year. The unfavorable results of the model can be caused by breaking the assumption of factor price equalization in case of Korean economy. Authors also conclude that given the rapidly industrializing environment of Korea despite the unfavorable results of the static model, testing longer time period with a dynamic model could bring support to Rybczynski Theorem.

As we can see, results of empirical studies contradicting theoretical outcomes of Heckscher-Ohlin theory are usually caused by breaking one or more of the assumptions of Heckscher-Ohlin model. The model itself is based on some strong assumptions and it would be appropriate to study them more deeply and show what happens if the assumptions are broken and how to deal with it. To focus on the influence of factor supplies, Heckscher-Ohlin model assumes that (1) technology across all countries is identical with constant returns to scale, (2) homogeneity of preferences across all countries, (3) no trade barriers and perfect competition, (4) full mobility of production factors within the countries but on the other hand no mobility of production factors across the countries and (5) equal number of goods and factors used in the model.

By assuming that technology is the same across all countries we suppress the differences in factor requirements. This assumption says that given good can be produced using the same combination and amounts of factors in all the countries. Given the identical technology assumption, we can derive the production constraints directly from amounts of available production factors and we can compare them across the countries. Constant returns to scale rule out the influence of country size. Moreover with increasing returns to scale we would have to include the effects of possible specialization into the model.

Homogeneity of preferences tells us that structure of demand is the same in all countries in other words this means that indifference curves remains the same across the countries. This assumption ensures that we will be able to find a unique solution when free trade is promoted among the countries.

Assumption of no trade barriers along with the assumption of perfect competition ensures that countries have no incentive to prefer one country over another as target of their exports or as a source of imports. Under these assumptions, distances of countries or transportation costs are not included in our calculations.

Full mobility of production factors within countries allows costless change of production patterns according to changes in demand or foreign supply conditions. On the contrary, no mobility of factors across the countries makes all changes of demand and production possibilities (in form of factor endowments) to promote trade of goods.

To reach the algebraic solution we require that the model has the same number of goods and factors of production.

Some of the assumptions of Heckscher-Ohlin model may seem too drastic, making the model very poor for describing real world situations. As we already discussed in the literature review, many authors solve the assumption problems by modifying the basic model and using more sophisticated methods to find the relations between the trade or output and relative factor endowments. Model used by RECHER, CHOUDHRI (1993) for instance deals with the case where factor prices are not equal between countries. They introduce three variants of the model, the variant that allow imperfect factor mobility within each country, shows especially favorable results that support Heckscher-Ohlin predictions. Another test dealing with the case where factor prices are not equal between countries was done by CHOI, KRISHNA (2004). Test by ROMALIS (2004) implements Paul R. Krugman's (1980) model of monopolistic competition and transport costs into the Heckscher-Ohlin model. Romalis is using a multi-country version of the model and assumes that commodity structure of production and bilateral trade is fully determined. Results of his test correspond with the hypothesis that countries that rapidly accumulate a factor see their production and export structures systematically shift towards industries that intensively use that factor. HARRIGAN, ZAKRAJŠEK (2000) implement estimation of immeasurable technological differences into their model. In addition to the main factor abundance hypothesis they also consider an alternative hypothesis that the level of aggregate productivity by itself can explain specialization. Results of their tests support the hypotheses and show the importance of factor endowments on specialization.

4 GENERAL ANALYSIS

4.1 Hypothesis

The Heckscher-Ohlin model predicts certain pattern of trade. First, comparative advantages arising from initial factor endowments determine the directions of trade flows. Second, trade volume is expected, ceteris paribus, to be positively correlated with the difference in relative factor endowments of the trading countries. A capital-abundant country is expected to trade more with a labor-abundant country than with another capital-abundant country. Finally, increased trade is expected to be associated with substantial income distribution effects. The promotion of free trade raises revenues of industries that intensively use the relatively abundant factor and lowers revenues of industries that use the relatively scarce one more intensively.

These fundamental predictions make us consider what effects we should expect to occur in the case of the Czech Republic. As we already discussed above in the part regarding the development of the Czech Republic foreign trade, main part of the Czech republic's exports in 2005 was formed by the engineering and transport equipment industries as well as electronics, computers and industrial machinery industries all of which could be considered capital-intensive.

On the other hand, we need to take into account the trade partners of the Czech Republic. The crucial variable which determines the structure of the trade according to the Heckscher-Ohlin theory is relative factor abundance. In case of the Czech Republic, the relativity makes a big difference in our view of the whole situation. The biggest trade partners of the Czech Republic are the Western European countries, especially Germany. Given that in 2005, the Czech Republic was already a member of the European Union, foreign trade with the EU member states deepened even further at the expense of non-EU countries, due to changes in tariff structure compared to pre-EU-accession era. Now if we compare the relative capital abundance of the Czech Republic with the Western European countries we would expect the Western European countries to be relatively more capital abundant.

If we proceed on the assumption of relative capital abundance of the Western European countries, the Heckscher-Ohlin theory would then predict that the Czech exports should be relatively more labor intensive than the Czech imports. I believe that this assumption is realistic and therefore I expect the results of the analysis described further below to show Czech exports more labor intensive than the Czech imports.

4.2 Approach to the testing – Input-output analysis

As already discussed above in the section dealing with the Heckscher-Ohlin model, according to the theory of comparative advantage represented in our case by the Heckscher-Ohlin model, we expect countries to specialize according to their factor endowments. The real-world evidence however seemed to show rather different behavior. This has led many economists to compile various empirical tests of the factor abundance theory. Wassily W. Leontief, a Nobel Prize winner, devoted his studies to input-output analysis and describing how changes in one economic sector may have an effect on other sectors. In the year 1953, Leontief came up with a method to test the relationships predicted by the Heckscher-Ohlin model using input-output tables for the US economy. This method is called input-output analysis, nowadays. In his first test, Leontief reached a paradoxical conclusion that the United States, as the most capital abundant country in the world at the time, exported labor-intensive commodities and imported capital-intensive commodities. This result has come to be known as the Leontief Paradox.

The method for testing the predicted H-O relationships used in my research is based on the input-output analysis introduced by LEONTIEF (1956) in his second test of the Heckscher-Ohlin model and the methodology presented by EUROSTAT (2008).

The structure of each sectors' production activity is represented by appropriate structural coefficients that describe in quantitative terms the relationships between the inputs it absorbs and the output it produces. The interdependence among the sectors can be described by a set of linear equations which express the balances between total input and output of each good and service produced.

The cornerstone of input-output analysis is the input-output table. In a matrix form, it describes the flow of goods and services between all sectors of an economy over a period of time, usually in a given year. At the same time, it provides the required information on all inputs which are used in production: intermediates and production factors (labor, capital, and land). Input-output analysis is a method of quantifying the mutual relationships among the various sector of the economy. The objective of input-output analysis is to describe and analyze the production structure of an economy. Production processes in an economy are always interdependent. The products of one industry are used in another while the product of that industry may be used in many others. As stated by the Eurostat[3], '*Input-output analysis is not only a system of quantifying the production of commodities by means of commodities but also a system of value added chains in interdependent markets. In a time of global markets with more competition and interdependent production, deeper division of labor and greater diversity and complexity of products, the exchange of intermediates becomes more important and, consequently, so does input-output analysis.*'

Input-output analysis starts with the calculation of input-output coefficients. They are calculated by dividing each entry of the input-output table by the corresponding column total. The input coefficients can be interpreted as the corresponding shares of costs for goods, services and primary inputs in total output. As the input coefficients cover all inputs including the residual variable 'operating surplus' they add up to unity.

For domestic intermediates, imported intermediates and value added the input coefficients of a sector are defined as:

$$a_{ij} = x_{ij} / x_j \qquad (4\text{-}1)$$

a_{ij} = input coefficient

x_{ij} = flow of commodity (primary input) i to sector j

x_j = output of sector j

The input-output model used in my analysis is the static input-output system of Wassily Leontief. It is a linear model which is based on Leontief production functions and a given vector of final demand. The objective is to calculate the output levels for the individual sectors for the given final demand.

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[3] Eurostat. *Eurostat manual of supply, use and input-output tables.* 2008 edition. 2008

The balance between total input and outputs can be described by the following set of equations:

$$\begin{aligned} x_{11} + x_{12} + \ldots + x_{1n} + x_{1d} &= x_1 \\ x_{21} + x_{22} + \cdots + x_{2n} + x_{2d} &= x_2 \\ &\vdots \\ x_{n1} + x_{n2} + \ldots + x_{nn} + x_{nd} &= x_n \end{aligned} \qquad (4\text{-}2)$$

x_{ij} = intermediates from sector i to sector j

x_{id} = final demand for commodity i

x_j = output of sector j

We assume that all sectors produce with linear Leontief production functions. All inputs are used in fixed proportions in relation to output. It is assumed that a substitution of inputs is impossible. If we accept the assumption that the sectors produce with fixed technical input coefficients, we can use the input coefficients (4-1) to rewrite the equation system (4-2) replacing x_{ij} by $a_{ij}x_j$.

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + x_{1d} &= x_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n + x_{2d} &= x_2 \\ &\vdots \\ a_{n1}x_1 + a_{n2}x_2 + \ldots + a_{nn}x_n + x_{nd} &= x_n \end{aligned} \qquad (4\text{-}3)$$

This set of equations is then further transformed into the Leontief equation system.

$$\begin{aligned} (1 - a_{11})x_1 - a_{12}x_2 - \ldots - a_{1n}x_n &= x_{1d} \\ -a_{21}x_1 + (1 - a_{22})x_2 - \ldots - a_{2n}x_n &= x_{2d} \\ &\vdots \\ -a_{n1}x_1 - a_{n2}x_2 - \ldots + (1 - a_{nn})x_n &= x_{nd} \end{aligned} \qquad (4\text{-}4)$$

According to the Eurostat[4], *the equation system has the following features:*

- *final demand (exogenous variable) is isolated on the right side of the equation,*

[4] Eurostat. *Eurostat manual of supply, use and input-output tables.* 2008 edition. 2008

- *net output (output less intrasectoral consumption) is identified on the diagonal of the matrix,*
- *inputs have a negative sign, output have a positive sign.*

To solve the equation system (4-4) it is appropriate to rewrite the problem in matrix notation. For this purpose, we define the technology matrix A as the matrix of input coefficients for domestic intermediates.

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{pmatrix} \tag{4-5}$$

a_{ij} = input coefficients for domestic intermediates defined in (1)

Since the input-output table is symmetric, the technology matrix A is a square matrix. When we rewrite (4-3) in matrix notation, we get the following equations:

$$Ax + y = x \tag{4-6}$$

$$x - Ax = y \tag{4-7}$$

$$(I - A)x = y \tag{4-8}$$

The solution of this linear equation system is:

$$x = (I - A)^{-1} y \tag{4-9}$$

A = technology matrix

I = unit matrix

$(I - A)$ = Leontief matrix (equivalent to the Leontief equation system (4-4))

$(I - A)^{-1}$ = Leontief inverse

y = vector of final demand

x = vector of output

Vector Ax reflects the requirements for intermediates, while vector y represents the exogenous aggregate final demand. The matrix $(I - A)$ is called Leontief matrix.

We can use the Leontief inverse matrix to compute the cumulative input coefficients. We get these coefficients by computing total for each column of the Leontief inverse matrix. The cumulative input coefficients reflect the direct and indirect requirements for domestic intermediates for one unit of final demand.

These cumulative coefficients are sometimes also called multipliers as they measure the multiplicative effect of industry's production. As suggests ANALYSIS OF INTERDEPENDENCE STRUCTURES: INPUT-OUTPUT[5], *'Empirically derived multipliers represent the period for which the underlying relationships have been quantified. Such relationships do not just change („structurally") over the long-haul but are sensitive to cyclical variations. Particular reference should be made to the tendency that during boom periods (when the region may run out of local resources) multipliers tend to decrease, while spatial efficiencies and local loyalties may enhance the multiplier during downturns.*

Multiplier effects are not necessarily occurring after the specified exogenous stimulus. Thus, in addition to the difference between short- and long-run multipliers, one may have to consider that multiplier-related behaviors can be based on expectations and may thus occur in advance of the actual stimulus. In general, moving the (comparative-) static multiplier concept into a (e.g. forecasting) context where time is more explicitly considered can be tricky.'

As we already discussed above, for purposes of our research we assume that substitution of inputs is impossible and that all sectors produce with fixed technical input coefficients. Therefore, we can now multiply the inverse matrix $(I - A)^{-1}$ by a new independently derived or forecasted final demand vector to obtain the level of gross output for each industry necessary to satisfy this final demand.

We use this property of the Leontief inverse to determine the total quantity of production factors absorbed in production of one million Euros worth of exports or imports. To simulate this effect, we calculate a vector of coefficients showing export

[5] *Analysis of Interdependence Structures: Input-Output*, [found online: http://faculty.washington.edu/krumme/systems/multp.html], [2000?], downloaded 13.12.2011

and import proportions of individual industries. For exports, we define the elements of this vector as:

$$ex_i = EX_i / EX_{tot} \qquad (4\text{-}10)$$

ex_i = export proportion coefficient of industry i

EX_i = export of industry i (supplied from both domestic sources and imports)

EX_{tot} = total exports

We derive the import proportion coefficient vector in a similar way:

$$im_i = IM_i / IM_{tot} \qquad (4\text{-}11)$$

im_i = import proportion coefficient of industry i

IM_i = imports of industry i (used both in production and for direct consumption)

IM_{tot} = total imports

To determine the change[6] in the vector of final demand due to increase of exports by 1 million Euros we add the vector of export proportion coefficients to the vector of final demand:

$$y_{ex} = y + ex \qquad (4\text{-}12)$$

y_{ex} = vector of final demand after the increase in exports

y = vector of final demand

ex = vector of export proportion coefficients

Similarly we can determine the change in vector of final demand induced by the production of goods equivalent to 1 million Euro worth of imports:

[6] We add the vector of export (import) proportion coefficients to the original demand vector to illustrate the increase in demand. Since we substract the original levels of capital and labor from the derived total labor and capital requirements later on in (4-18) – (4-21), this procedure is equivalent to computing the capital and labor requirements for the additional demand induced by increase in exports or imports directly from vector *ex* or *im* respectively.

$$y_{im} = y + im \quad (4\text{-}13)$$

y_{im} = vector of final demand after adding production of goods equivalent to 1 million Euro worth of imports

y = vector of final demand

im = vector of import proportion coefficients

At this point, we use the equation (4-9) and by multiplying the inverse matrix $(I - A)^{-1}$ by a new final demand vector (either y_{ex} or y_{im}) we obtain the level of output for each industry necessary to satisfy the final demand increased by 1 million Euro worth of exports:

$$x_{ex} = (I - A)^{-1} y_{ex} \quad (4\text{-}14)$$

x_{ex} = vector of output induced by the increased exports

$(I - A)^{-1}$ = Leontief inverse

y_{ex} = vector of final demand after the increase in exports

Respectively for imports:

$$x_{im} = (I - A)^{-1} y_{im} \quad (4\text{-}15)$$

x_{im} = vector of output induced by adding production of goods equivalent to 1 million Euro worth of imports

$(I - A)^{-1}$ = Leontief inverse

y_{im} = vector of final demand after adding production of goods equivalent to 1 million Euro worth of imports

Using the input coefficients calculated in (4-1) we can now determine the levels of capital and labor needed to produce these new levels of final output.

$$K_{ex} = \sum k_{ex,i} = \sum a_{ki} x_{ex,i} \quad (4\text{-}16)$$

K_{ex} = total capital needed to produce output after the increase in exports

$k_{ex,i}$ = capital needed to produce output after the increase in exports in industry i

a_{ki} = input coefficient corresponding to direct capital input into industry i

$x_{ex,i}$ = output of industry i after the increase in exports

$$L_{ex} = \sum l_{ex,i} = \sum a_{li} x_{ex,i} \quad (4\text{-}17)$$

L_{ex} = total labor needed to produce output after the increase in exports

$l_{ex,i}$ = labor needed to produce output after the increase in exports in industry i

a_{li} = input coefficient corresponding to direct labor input into industry i

$x_{ex,i}$ = output of industry i after the increase in exports

We can derive the amounts of total capital and labor needed in case of increase in total output due to adding production of goods equivalent to 1 million Euro worth of imports similarly. In equation (4-16) resp. (4-17) we'd need to swap the industry outputs $x_{ex,i}$ by the outputs $x_{im,i}$ given in equation (4-15).

By subtracting the original levels of capital and labor needed to produce the final output y we get the capital (labor) requirements to produce 1 million Euro worth of exports or imports respectively.

$$r_{k,ex} = K_{ex} - K \quad (4\text{-}18)$$

$$r_{k,im} = K_{im} - K \quad (4\text{-}19)$$

$$r_{l,ex} = L_{ex} - L \quad (4\text{-}20)$$

$$r_{l,im} = L_{im} - L \quad (4\text{-}21)$$

$r_{k,ex}$ = capital required to produce 1 million Euro worth of exports

$r_{k,im}$ = capital required to produce 1 million Euro worth of imports

$r_{l,ex}$ = labor needed to produce 1 million Euro worth of exports

$r_{l,im}$ = labor needed to produce 1 million Euro worth of imports

K_{ex} = total capital needed to produce output after the increase in exports

K_{im} = total capital needed to produce output after the increase in imports

L_{ex} = total labor needed to produce output after the increase in exports

L_{im} = total labor needed to produce output after the increase in imports

K = total capital needed to produce the original output

L = total labor needed to produce the original output

Finally, we use the factor requirements (4-18) – (4-21) to compute the capital-labor ratios for exports and imports. These ratios show us relative factor intensity of exports and imports respectively.

$$k_x = r_{k,ex} / r_{l,ex} \qquad (4\text{-}22)$$

$$k_m = r_{k,im} / r_{l,im} \qquad (4\text{-}23)$$

k_x = capital-labor ratio for exports

k_m = capital-labor ratio for imports

$r_{k,ex}$ = capital required to produce 1 million Euro worth of exports

$r_{k,im}$ = capital required to produce 1 million Euro worth of imports

$r_{l,ex}$ = labor needed to produce 1 million Euro worth of exports

$r_{l,im}$ = labor needed to produce 1 million Euro worth of imports

By comparing the capital-labor ratios for exports and imports we can determine if the exports are more capital-intensive than imports or vice versa.

4.3 The Data

The production structure of an economy is described in an input-output table. The table consists of four quadrants. The columns of the matrix represent the economic activities of the economy: production sectors (individual industries) in columns of quadrant I and III and categories of final demand (consumption) in columns of quadrants II and IV. The corresponding inputs of these activities are reported in the rows of the matrix: products of individual industries in rows of quadrant I and II and primary inputs (wages, capital, operating surplus) in rows of quadrant III and IV. The rightmost column represents total output and the lowermost row represents total inputs. A simple example of an input-output table is given in Table 4-1.

Table 4-1 *Example of an input-output table*

	Industries	Consumption	Output
Industries	Quadrant I	Quadrant II	
Value added	Quadrant III	Quadrant IV	
Input			

Quadrant I includes the requirements for intermediate inputs in production (intermediates). They include goods and services which are produced to be used by companies in individual industries for further production. This part of the input-output table is used for computing the technical (input) coefficients and then the Leontief matrix and Leontief inverse. In quadrant II the final use of goods and services for consumption and investment is reported (final demand). Quadrant III contains the requirements of each sector for primary inputs (labor, capital). In quadrant IV normally no transactions are denoted, as very few market transactions are reported in this sphere. The columns of an input-output table represent the cost structure of a sector and the corresponding rows the composition of its revenues.

The disaggregation of branches in an input-output table helps to establish detailed information on the interdependencies in production between the various sectors of the economy. At the same time the structural composition of the final demand components (consumption, investment, exports) in terms of purchased goods and services is included in an input-output table. The residual variable 'operating surplus' is calculated as the difference between revenues and costs. Therefore, in input-output tables with currency units, row and column sums of the matrix match with the consequence that for each sector input equals output.

For purposes of input-output analysis and thus computing the technical coefficients, the symmetric input-output table should be accompanied by at least two tables:

- symmetric matrix showing the use of imports and
- symmetric input-output table for domestic output.

Namely, the input-output table for domestic output is used in calculating the cumulated coefficients, by the Leontief-inverse. This matrix is the inverse of the difference between the identity matrix I and the matrix of technical coefficients. By multiplication of the Leontief-inverse with the vector of final demand the vector of total output by product can be compiled.

In input-output analysis, two types of input-output tables are distinguished. The only difference between the two types of tables is given by the structure of quadrant I and II of given table. While the core of the 'aggregate' table includes flows for both domestic and imported products, the 'extended' input-output table shows the flows for domestic output and the imported products separately. In case of the 'extended' input-output table, imports can be either aggregated to one row vector of imports or they can be described separately for each industry, similarly to the domestic inputs.

Table 4-2 *Aggregate input-output table*

	Industries	Consumption	Output
Industries	Intermediates (both domestic and imported)	Final use (both domestic and imported products)	
Value added	Primary inputs		
Input			

Table 4-3 *Extended input-output table*

	Industries	Consumption	Output
Industries	Intermediates (domestic only)	Final use (domestic products)	
Imports	Intermediates (imported)	Final use (imported products)	
Value added	Primary inputs		
Input			

The use of aggregate tables and extended tables differ according to the objective of a study they are used for. Domestic intermediates and final demand commodities may be substituted by foreign goods and services if relative prices and exchange rates change in an unfavorable way for the domestic economy. It can be assumed that the aggregate input-output table is a more appropriate form to identify stable cost components and technical input relations while the extended input-output table is the better option to study the impact on the domestic economy and import substitution.

For analytical purposes I transformed the domestic input-output table and the input-output table for imports provided by Eurostat into one table of the 'extended' format. I used the flows of domestic intermediates to compute the input coefficients of individual industries. To compute the proportion coefficients, however, I needed the aggregated data for both domestic and imported products.

I have used the input-output tables for year 2005. Although the data are not the most recent ones, the dataset for year 2005 is the most comprehensive one available from the Eurostat database (as well as Czech Statistical Office). As already mentioned above, we need both the symmetric input-output table for domestic output and the full (domestic plus imports) symmetric input-output table to calculate the technical coefficients and Leontief-inverse matrix. In 2005, the Czech Republic was already a member of the European Union. As already discussed above, EU admission had a significant impact on the foreign trade of the Czech Republic. Thus, the data for year 2005 should be comparable to the current situation. I believe that the technical coefficients derived from the data should be sufficiently stable over time to provide objective insight into the structure of foreign trade of the Czech Republic.

4.4 Analysis of the results

Let me first revise what we wanted to show by our calculations. To test the viability of Heckscher-Ohlin model on case of the Czech Republic, we needed to measure factor intensities of Czech exports and imports. In order to evaluate the correspondence of actual export-import structure with the one predicted by the theoretical model, given our assumptions about the relative factor abundance, I have computed capital-labor ratio for export and import bundles. In other words, I have computed the relative amounts of capital and labor needed to produce one million Euro worth of exports or imports respectively. The results of my calculations are summarized in the table 4-4.

Table 4-4 *Capital and labor requirements per 1 mil.* € of *Czech exports and imports, mil. Euro*

	Capital requirement	Labor requirement	Capital/Labor ratio
Exports	0.0842	0.2328	0.3615
Imports	0.0901	0.2255	0.3997

We can see from the results that Czech exports are less capital intensive than Czech imports. If we compare the capital-labor ratios of the two we can see that imports are in fact 10.55% more labor intensive than exports.

We should also consider once again all the assumptions that could have impact on the results of the testing. First, to ensure fixed proportions of production factors and thus stability of technical coefficients, we assumed that all sectors of the economy produce with the Leontief production functions. We used this assumption to simulate and measure the effect of increase in exports or imports. If we had neglected the assumption of Leontief production functions, we wouldn't be able to estimate the capital/labor ratios of export and import bundles. We also assumed that the increase in exports and imports will be proportional across individual industries according to the current exports and imports of given industry. This assumption makes the estimated capital/labor ratios applicable to the whole exports and imports of the Czech Republic. It is obvious that if we change the contribution of individual industries in exports or imports respectively, we also came up with different labor and capital requirements and therefore also different values of capital/labor ratios for export and import bundles. Another important assumption comes directly from the Heckscher-Ohlin model. We assumed the technology across all countries to be identical with constant returns to scale. This assumption allowed us to use a single technology matrix derived from the Czech data to compute the capital and labor intensities for both exports and imports. As already discussed in the section about the assumptions of the Heckscher-Ohlin model, this assumption is crucial for comparing countries in the simple Heckscher-Ohlin model, but in confrontation with real-world evidence it may seem too drastic and have a significant influence on the results of testing.

5 CONCLUSIONS

5.1 Hypothesis validation

We can see that the results of input-output analysis correspond with the pattern of trade predicted by the Heckscher-Ohlin model. We predicted that given the Czech Republic trades mostly with the Western European countries, Czech exports should be more labor intensive than Czech imports. As we already discussed the assumptions of the used input-output analysis above, I'll focus on the assumptions of the Heckscher-Ohlin model here. My prediction was based on the assumption that the Czech Republic trades mostly with countries that are relatively more capital intensive. I based my assumption on the fact that the biggest trade partner and target of exports of the Czech Republic is Germany. Moreover, admission to the European Union and the associated changes in tariff structure led to a shift in trade towards the EU countries in general.

5.2 Summary

The presented thesis tested the viability of Heckscher-Ohlin model on a case of the Czech Republic. While developing a broad theoretical background and providing factual information about the development of the economy of the Czech Republic, I have adopted the method used by Wassily Leontief to test the factor-requirement structure of foreign trade of the Czech Republic. I have shown the mechanisms of the Heckscher-Ohlin model and then I followed by building a hypothesis about the foreign trade of the Czech Republic, based on the Heckscher-Ohlin predictions. By explaining the assumptions of the Heckscher-Ohlin model I have shown the pitfalls reached when using the model for describing real-world situations and the motivation for empirical testing of the model.

The actual testing method, the input-output analysis, showed to be quite demanding in terms of the data used in the calculations. Given the complexity of the data I was reliant on the data provided by Eurostat which were comprehensive but on the other hand not very actual. If I wanted to compile the current data from statistics provided for example by the Czech statistical office, it would be very demanding and time-consuming procedure.

In the thesis, I managed to meet the goal that I set at the beginning. I successfully tested if the Heckscher-Ohlin model is a viable theoretical concept for describing the foreign trade of the Czech Republic. Despite the strong assumptions of the theory, the empirical test showed results that support the Heckscher-Ohlin model.

Testing for the individual theorems derived from the Heckscher-Ohlin model as well as loosening some of the crucial assumptions of the model remains for future research.

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7 APPENDIX

Appendix I *– Data and computed capital and labor requirements per million Euro worth of exports and imports; thousands €*

No.	Commodity	requirements per 1 mil. Euro worth of exports		requirements per 1 mil. Euro worth of imports		exports per mil. Euro of total exports	imports per mil. Euro of total imports
		capital	labor	capital	labor		
01	Products of agriculture, hunting and related services	2,22	4,44	2,97	5,92	9,62	14,95
02	Products of forestry, logging and related services	0,53	1,51	0,36	1,03	2,22	1,10
05	Fish and other fishing products; services incidental of fishing	0,01	0,07	0,01	0,05	0,19	0,12
10	Coal and lignite; peat	1,16	3,02	0,98	2,54	6,78	2,16
11	Crude petroleum and natural gas; services incidental to oil and gas extraction excluding surveying	0,13	0,08	3,58	2,11	0,44	32,07
12	Uranium and thorium ores	0,29	0,99	0,03	0,10	0,63	0,06
13	Metal ores	0,00	0,00	0,00	0,00	0,01	3,76
14	Other mining and quarrying products	0,32	0,65	0,34	0,69	1,26	1,57
15	Food products and beverages	1,73	4,73	2,04	5,57	28,39	34,65
16	Tobacco products	0,07	0,15	0,06	0,12	1,61	1,37
17	Textiles	1,87	5,05	1,65	4,45	24,39	21,84
18	Wearing apparel; furs	0,34	2,71	0,32	2,52	12,63	11,75
19	Leather and leather products	0,14	0,82	0,22	1,29	4,20	6,71
20	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials	1,00	3,29	0,71	2,34	12,21	6,61
21	Pulp, paper and paper products	1,18	2,26	1,16	2,21	14,89	14,55

No.	Commodity	requirements per 1 mil. Euro worth of exports		requirements per 1 mil. Euro worth of imports		exports per mil. Euro of total exports	imports per mil. Euro of total imports
		capital	labor	capital	labor		
22	Printed matter and recorded media	1,01	3,19	0,95	3,00	10,90	9,89
23	Coke, refined petroleum products and nuclear fuels	0,61	0,50	1,20	1,00	8,90	34,92
24	Chemicals, chemical products and man-made fibres	2,88	6,00	3,68	7,67	50,86	67,36
25	Rubber and plastic products	2,78	8,64	2,91	9,04	42,78	50,85
26	Other non-metallic mineral products	2,66	6,47	1,66	4,03	29,91	15,83
27	Basic metals	3,76	7,41	3,93	7,75	53,97	62,71
28	Fabricated metal products, except machinery and equipment	3,14	16,08	2,39	12,25	56,75	41,43
29	Machinery and equipment n.e.c.	3,60	21,27	2,69	15,89	109,22	81,34
30	Office machinery and computers	0,16	0,98	0,15	0,91	54,55	50,73
31	Electrical machinery and apparatus n.e.c.	2,65	12,75	2,19	10,52	69,34	56,70
32	Radio, television and communication equipment and apparatus	0,85	3,74	0,99	4,38	47,69	55,87
33	Medical, precision and optical instruments, watches and clocks	0,55	3,33	0,68	4,07	14,86	18,20
34	Motor vehicles, trailers and semi-trailers	6,86	13,09	4,45	8,48	151,15	97,45
35	Other transport equipment	0,49	2,38	0,52	2,49	10,24	11,17
36	Furniture; other manufactured goods n.e.c.	0,95	5,39	0,61	3,45	32,16	20,34
37	Secondary raw materials	0,20	0,48	0,23	0,55	0,06	0,37

No.	Commodity	requirements per 1 mil. Euro worth of exports		requirements per 1 mil. Euro worth of imports		exports per mil. Euro of total exports	imports per mil. Euro of total imports
		capital	labor	capital	labor		
40	Electrical energy, gas, steam and hot water	5,56	2,58	7,32	3,39	8,93	19,25
41	Collected and purified water, distribution services of water	0,22	0,41	0,27	0,51	0,07	0,30
45	Construction work	0,52	2,69	1,30	6,69	2,58	23,79
50	Trade, maintenance and repair services of motor vehicles and motorcycles; retail sale of automotive fuel	0,65	2,01	0,77	2,39	0,90	4,03
51	Wholesale trade and commission trade services, except of motor vehicles and motorcycles	3,29	13,99	3,33	14,17	0,68	5,36
52	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods	2,33	10,13	2,25	9,75	2,35	2,00
55	Hotel and restaurant services	1,09	6,11	0,63	3,54	21,13	9,72
60	Land transport; transport via pipeline services	3,81	11,45	2,79	8,39	26,29	13,24
61	Water transport services	-1,89	-1,81	-1,77	-1,70	0,54	1,19
62	Air transport services	1,07	4,21	0,84	3,33	13,24	7,66
63	Supporting and auxiliary transport services; travel agency services	6,09	1,64	7,44	2,00	0,70	6,74
64	Post and telecommunication services	2,74	3,23	2,98	3,52	4,31	5,14
65	Financial intermediation services, except insurance and pension funding services	1,82	4,80	2,24	5,93	5,90	10,37

No.	Commodity	requirements per 1 mil. Euro worth of exports		requirements per 1 mil. Euro worth of imports		exports per mil. Euro of total exports	imports per mil. Euro of total imports
		capital	labor	capital	labor		
66	Insurance and pension funding services, except compulsory social security services	0,23	1,03	0,35	1,58	0,11	2,99
67	Services auxiliary to financial intermediation	0,09	0,30	0,12	0,39	0,00	0,17
70	Real estate services	5,36	0,60	7,00	0,78	0,43	6,88
71	Renting services of machinery and equipment without operator and of personal and household goods	0,92	0,42	1,19	0,54	0,86	1,65
72	Computer and related services	0,86	4,88	0,76	4,31	7,43	5,38
73	Research and development services	0,49	1,82	0,58	2,19	0,88	2,26
74	Other business services	2,00	13,64	2,39	16,32	20,90	25,50
75	Public administration and defence services; compulsory social security services	0,42	1,66	0,76	3,00	1,07	3,69
80	Education services	0,39	1,29	0,70	2,29	0,79	2,49
85	Health and social work services	0,22	1,34	0,48	2,96	2,45	6,01
90	Sewage and refuse disposal services, sanitation and similar services	0,64	0,91	0,87	1,24	0,03	1,36
91	Membership organisation services n.e.c.	0,12	0,22	0,20	0,39	0,00	0,46
92	Recreational, cultural and sporting services	0,85	1,36	0,66	1,05	4,56	3,23
93	Other services	0,11	0,44	0,03	0,12	3,24	0,71
95	Private households with employed persons	0,00	0,00	0,00	0,00	0,00	0,00