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Austrian Linkages to the European Economy and the Transmission Mechanisms of Economic Crisis

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Joseph Francois, Mario Holzner, Olga Pindyuk

Abstract

Like most of the global economy, Austria suffered from recession in 2008-2009. In this paper we deconstruct the pattern of recession, and the transmission of the global recession to Austria's economy. We provide a new a new breakdown of the value added in Austrian exports, tracing both upstream and downstream linkages and their role in the recession. We also employ a multi-region computable general equilibrium (CGE) model, focused on Austria and its major trading partners. We estimate the combined impacts of the crisis, as implemented through stylized shocks to investment and household demand across major trading partners. These are based on the actual global demand shocks that occurred in 2008-2009. As we are focused on recession, we work with a short-run version of the model, where labor markers are modeled with unemployment and sticky wages, and where industry structure (number of varieties and allocation of capital stock across industries) is fixed. We introduce demand shocks (changes) to global investment demand calibrated from actual investment demand changes during the recession. We also calibrate output shocks based on actual changes in GDP in this period. The focus on backward and forward linkages provides new insight into the transmission channels for focused demand shocks at the border into more diffuse shocks within the broader Austrian economy. While the drop in global demand during the recent recession was focused on sectors producing heavy investment goods, the actual pressure this placed on the Austrian economy also hinged on the linkages of these sectors to other elements of the Austrian economy.

Keywords: economic crisis, transmission mechanisms, Austria, Europe, CGE

JEL-codes: F14, F44, F47, C68

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Austrian Linkages to the European Economy and the Transmission Mechanisms of Economic Crisis

J. Francois, M. Holzner, O. Pindyuk

FIW – Research Centre International Economics

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Zusammenfassung

Die jüngste Rezession zeichnete sich durch dramatische Veränderungen im Handel aus. In der Suche nach den Gründen hierfür geht die aktuelle Literatur von der Annahme aus, dass der Zusammenbruch des Handels beispiellos war, dass er mit dem allgemeinen Niveau des wirtschaftlichen Rückgang inkonsistent war und dass er eine Reihe von handelsbezogenen Problemen aufzeigt, die handelsspezifische Lösungen erfordern. Für Österreich hat dies einen starken Druck auf jene Produktionszweige bedeutet, die in enger Verbindung mit seinen EU-Partnern stehen, vor allem Deutschland. Der Kollaps der Exporte der verarbeitenden Industrie in der EU übertrug sich auf die damit verbundenen Branchen in Österreich.

Die österreichische Wirtschaft konnte eine Rezession zwar nicht vermeiden, schnitt aber besser ab als der Rest der EU15: Österreichs BIP fiel 2008-2009 um insgesamt 1,8%, d.h. um 2 Prozentpunkte weniger als das BIP des wichtigsten Handelspartners Deutschland und um 1,9 Prozentpunkte weniger als das durchschnittliche BIP der EU15. Die neuen EU-Mitgliedstaaten konnten im Durchschnitt (obwohl sie sehr heterogen sind, was ihre Wirtschaftsleistung betrifft) eine Rezession vermeiden und verzeichneten ein geringes positives Wachstum von insgesamt 1%. Jene mittel- und osteuropäischen Staaten, welche die wichtigsten Handelspartner Österreichs in der Region sind, stellten sich als die robustesten Wirtschaften heraus.

Um die Rezession der österreichischen Wirtschaft zu analysieren, wenden wir ein multiregionales berechenbares allgemeines Gleichgewichtsmodell (CGE) mit Schwerpunkt auf Österreich und seine Haupthandelspartner an, das uns eine Einschätzung der kombinierten Auswirkungen der Krise – via Schocks auf Investitionen und Nachfrage der Haushalte in den Haupthandelspartnern – ermöglicht. Wir arbeiten mit einer kurzfristigen Version des Modells. Die Arbeitsmärkte sind mit Arbeitslosigkeit und unflexiblen Löhnen modelliert, während die Industriestruktur (Zahl der Varianten und Verteilung des Kapitalstocks quer über die Industriezweige) fix ist. Sodann führen wir Schocks bzw. Veränderungen für die globale Investitionsnachfrage ein, abgeglichen auf tatsächliche Änderungen in der Investitionsnachfrage 2007-2009. Wir kalibrieren auch Output-Schocks, die auf tatsächlichen Änderungen im BIP 2007-2009 basieren.

Die Ergebnisse unserer Simulation zeigen, dass die EU13 (d.h. die EU15 minus Österreich und Deutschland) unter allen Handelspartnern Österreichs am meisten zum Rückgang des österreichischen BIP beitrug. Deutschland, das fast den gleichen Anteil an Österreichs Exporten und etwa dieselbe Rate des BIP-Rückgangs aufweist, zeigte einen weit weniger negativen Einfluss auf Österreichs BIP. Ein möglicher Grund dafür ist der wesentlich stärkere Rückgang der Investitionen in der EU13 als in Deutschland, der Österreichs Exporte – die von Gütern für den Investitionsbedarf dominiert sind – stärker negativ betraf. Die

Auswirkungen der EU12 auf die österreichische Wirtschaft während der Krise waren fast gleich Null und federten daher, wie erwartet, die Krise eher ab.

Aus dem Blickwinkel der sektoralen Nachfrage hatte der Rückgang der globalen Nachfrage nach Maschinen unter allen Sektoren die stärkste Auswirkung auf die österreichische Wirtschaft. Dieser Rückgang war so schwerwiegend, dass er allein einen Rückgang in Österreichs BIP in einem Ausmaß verursachen konnte, das vergleichbar mit jenem ist, zu dem es durch die globale Rezession kam. Danach folgen Kraftfahrzeuge, was die Auswirkungen auf den BIP-Rückgang betrifft. Die Dienstleistungssektoren scheinen im Vergleich zur verarbeitenden Industrie einen weniger negativen Einfluss auf die österreichische Wirtschaft ausgeübt zu haben.

Executive Summary

The recent recession has been accompanied by dramatic changes in trade. The focus in the recent academic literature has been on finding the cause, and the assumption has been that the collapse in trade is unprecedented, inconsistent with the general level of economic downturn, and indicative of a trade-related set of problems calling for trade-specific solutions. For Austria, the recession has involved strong pressure on manufacturing sectors linked closely to its EU partners, and especially to Germany. As EU manufacturing has cycled through export collapse, this has translated into impacts on Austria as well.

The Austrian economy performed better in recession compared with the rest of the EU15. Its GDP during 2008-2009 fell cumulatively by 1.8%, which was 2 p.p. smaller than decline of GDP of its major trading partner Germany, and 1.9 p.p. smaller than the average decline of the EU15 economy. New EU member states, on average had small positive cumulative growth (around 1%), and in this sense Central and Eastern European countries, major trading partners of Austria, turned out to be relatively robust.

In order to dissect recession of the Austrian economy, we employ detailed data on the industrial structure of Austria's economy. We provide a new breakdown of the value added in Austrian exports, tracing both upstream and downstream linkages. We also use these data in a multi-region computable general equilibrium (CGE) model that is focused on Austria and its major trading partners. This enables us to estimate the combined impacts of the crisis, as implemented through stylized shocks to investment and household demand across major trading partners. To examine the recession, we work with a short-run version of the model, introducing demand shocks (changes) to global investment demand calibrated from actual investment demand changes from 2007-2009. We also calibrate output shocks based on actual changes in GDP from 2007-2009.

As the results of our simulations show, EU13 (EU15 without Austria and Germany) contributed the most to the Austria's GDP fall among its trading partners. Germany, which accounts for practically the same share of Austrian exports and experienced almost the same rate of GDP decline, had much lower negative impact on the Austrian GDP. A possible reason for this can be the much stronger decline in investment in the EU13 as compared with Germany, which affected Austrian exports, dominated by investment demand goods, more heavily. The EU12's effect on the Austrian economy during the crisis was close to zero, thus as expected, they rather cushioned the country from the crisis.

From the sectoral demand perspective, the fall in global demand for machinery had the biggest impact on the Austrian economy among all sectors. The fall was so severe, that it alone could cause a decline in Austria's GDP of the scale comparable to one brought about by the global recession. Machinery is followed by motor vehicles in terms of the

scale of impact on GDP. Global demand in the services sectors appears to have caused less direct damage to the Austrian economy as compared with manufacturing.

While the drop in global demand was focused on sectors producing heavy investment goods, the actual pressure this placed on the Austrian economy also hinged on the linkages of these sectors to other elements of the Austrian economy. On a value added basis, drop for demand in heavy industrial sectors placed negative pressure on services less exposed to the direct vagaries of the world economy, because the Austrian value added in these sectors includes a substantial share of producer services (IT, professional services, finance, and other business services). Indeed, a great deal of the value added contained in Austrian manufacturing exports comes from service inputs. As such, though the recession featured a disproportionate drop in global demand for heavy industrial and investment goods, in the Austrian context demand shocks in goods ultimately placed pressure on producer services as well.

Keywords: *economic recession, Austria, CGE-modeling, GTAP*

JEL classification: *C68, F17, F47*

CHAPTER 1: INTRODUCTION

The current recession has been accompanied by dramatic changes in trade. The trends in trade in late 2008, first spotted in early 2009, invited a mix of consternation and hyperbole in the business and economics press and blogosphere alike. Through the summer of 2009, discussion ranged from worries about export credit shortfalls to resurgent import protection. The focus has been on finding the cause, and the assumption has been that the collapse in trade is unprecedented, inconsistent with the general level of economic downturn, and indicative of a trade-related set of problems calling for trade-specific solutions. For Austria, the recession has involved strong pressure on manufacturing sectors linked closely to its EU partners, and especially to Germany. As EU manufacturing has cycled through export collapse and recovery, this translated into impacts on linked industries in Austria as well.

In this paper we examine the transmission of the economic crisis to Austria through trade-related channels. We employ detailed data on the industrial structure of Austria's economy. We provide a new breakdown of the value added in Austrian exports, tracing both up-stream and downstream linkages. We also use these data for a CGE application focused on Austria and its major trading partners. We use the model to dissect the crisis and its impact, estimating the mechanisms by which trade had transmitted crisis across borders. In the emerging academic literature on trade and the crisis, the papers closest to this approach focus on the sector composition of the downturn and trade. One set of explanations for the increased sensitivity of trade to GDP swings includes increased complexity in production. Freund (2009), for example, highlights fragmentation in production. She also notes that durable goods are most affected, historically, by financial downturns. This includes iron and steel. McKibbin and Stoeckel (2009) work with a CGE model modified to include elements of the financial crisis. They find that the drop in durables is much higher than for non-durables. In addition, the bursting of the housing bubble was identified as being most responsible for the drop in consumption and imports, while the change in assessment of risk was largely responsible for the drop in investment. Also working with a CGE model, Bénassy-Quéré, Decreux, Fontagné, and Khoudour-Castéras (2009) emphasize that a large part of the recent drop in the level of trade is linked to price rather than volume effects. They also stress the importance of using appropriate price deflators. GDP price deflators can lead to substantial overestimating of trade volume changes in economic downturns. Willenbockel and Robinson (2009) also use a CGE model, focusing on developing countries and the collapse in global commodity prices as the downturn unfolded. This literature has largely focused on the impact of the crisis on the United States, and to a more limited extent on the larger EU markets (France, Germany, and the OECD in general).

CHAPTER 2: AUSTRIA's TRADE AND PRODUCTION STRUCTURE

Direct analysis of the Austrian commodity exports structure (as presented in the usual trade statistics) reveals that machinery, motor vehicles and other light manufacturing account for 42% of Austrian exports. Services account for 31.3% of total exports, with transports, and IT and other business services making up the bulk of it. (Table 2.1)

Including intermediate linkages between sectors into the calculation of the sectoral shares in exports shows that services in reality play a more important role in exports: their share increases to 48.8%.[1] The increase comes at the cost of manufacturing sectors (apart from processed food); the highest services content relative to exports value turns out to be in other machinery and motor vehicles.

Table 2.1

Commodity structure of Austria's exports in the base year[2], %

	Direct shares	Shares accounting for intermediate linkages
Agriculture, forestry, fish	0.6	1.9
Energy extraction	0.2	0.8
Petrochemicals	0.2	1.2
Processed food	4.0	4.2
Textiles and clothing	2.7	2.3
Chemicals and plastics	8.6	6.2
Other light manufacturing	11.3	9.2
Metals	8.2	5.8
Motor vehicles	10.1	6.2
Transport equipment	2.3	1.2
Other machinery	20.6	12.3
Utilities	0.6	1.5
Construction	0.9	1.9
Communications	0.7	1.9
Transport	10.9	17.3
IT and other business services	12.8	16.9
Finance and insurance	2.5	4.2
Consumer services	1.2	1.9
Other Services	1.7	3.1
Total	100.0	100.0

Source: GTAP, wiiw calculations.

Judging by direct shares, Austria seems to be one of the most services-intensive economies globally (see Table 2.2). The share of services in the country's exports is more than twice as high as in Germany and 6 p.p. higher than in the EU13 (EU15 without Austria and Germany).

[1] For the methodology of calculation of exports sectoral structure accounting for indirect linkages see Appendix C.

[2] The version of the GTAP used in this paper has 2007 as a base year.

Table 2.2

Commodity structure of exports in the base year, %

	AUT	DEU	EU13	EU12	CHE	East Asia	South East Asia	South Asia	NAFTA
Agriculture, forestry, fish	0.6	0.8	2.1	1.8	0.5	0.6	1.8	4.0	3.6
Energy extraction	0.2	0.2	1.5	0.7	0.2	0.4	5.7	3.7	4.0
Petrochemicals	0.2	0.5	1.8	1.8	0.0	1.0	2.3	2.7	1.5
Processed food	4.0	3.7	6.3	4.1	2.2	1.3	6.1	5.8	3.4
Textiles and clothing	2.7	2.5	3.5	6.4	1.5	8.1	5.6	27.0	2.1
Chemicals and plastics	8.6	14.8	15.9	8.7	22.9	9.2	10.8	9.0	11.7
Other light manufacturing	11.3	6.5	8.1	11.8	6.5	7.3	8.3	15.2	7.2
Metals	8.2	7.1	6.1	9.0	11.9	6.5	3.4	6.7	5.1
Motor vehicles	10.1	18.9	9.0	13.1	1.0	8.6	1.6	1.7	11.2
Transport equipment	2.3	2.7	2.6	2.0	1.5	2.3	1.0	1.0	4.9
Other machinery	20.6	29.8	18.1	24.5	28.3	42.6	41.2	5.1	25.5
Utilities	0.6	0.4	0.3	1.8	1.0	0.1	0.0	0.1	0.2
Construction	0.9	0.7	0.6	0.6	0.1	0.5	0.3	0.3	0.3
Communications	0.7	0.4	1.0	0.7	0.9	0.2	0.4	1.0	0.6
Transport	10.9	3.1	7.7	5.9	5.3	6.9	5.7	4.5	5.0
IT and other business services	12.8	4.7	8.7	3.9	5.5	2.5	3.5	8.8	5.5
Finance and insurance	2.5	1.3	3.5	0.7	6.9	0.7	0.9	0.9	2.6
Consumer services	1.2	0.5	1.5	1.3	0.8	0.4	0.8	0.4	2.0
Other Services	1.7	1.5	1.6	1.0	3.1	0.9	0.5	2.2	3.6
Total	100	100	100	100	100	100	100	100	100
Total services	**31.3**	**12.6**	**24.9**	**15.9**	**23.6**	**12.2**	**12.1**	**18.2**	**19.8**

Source: GTAP, wiiw calculations.

Table 2.3

Commodity structure of exports in the base year, accounting for intermediate linkages, %

	AUT	DEU	EU13	EU12	CHE	East Asia	South East Asia	South Asia	NAFTA
Agriculture, forestry, fish	1.9	1.6	2.5	4.3	1.3	2.9	5.4	14.9	2.2
Energy extraction	0.8	1.2	1.9	2.5	0.7	2.4	5.1	4.5	2.6
Petrochemicals	1.2	1.9	1.9	2.5	0.7	2.1	4.0	4.0	2.0
Processed food	4.2	4.7	6.3	7.7	4.3	4.5	7.6	8.5	4.2
Textiles and clothing	2.3	1.9	2.8	4.0	1.6	4.5	4.7	11.8	2.0
Chemicals and plastics	6.2	7.8	8.8	7.1	11.2	8.4	9.1	7.1	6.3
Other light manufacturing	9.2	5.6	6.9	8.6	6.3	6.0	6.2	5.9	5.3
Metals	5.8	5.3	5.0	6.7	6.6	7.3	3.6	5.0	3.9
Motor vehicles	6.2	9.6	5.0	6.4	1.6	4.7	2.2	0.7	4.6
Transport equipment	1.2	1.2	1.6	1.2	1.0	1.0	1.1	0.7	1.8
Other machinery	12.3	14.0	9.4	12.9	13.5	18.3	22.8	2.4	10.1
Utilities	1.5	1.9	1.6	4.0	1.3	2.1	1.8	4.0	2.4
Construction	1.9	1.2	1.6	2.1	1.0	0.5	0.4	0.7	1.5
Communications	1.9	1.9	2.2	2.1	2.6	1.6	0.7	0.9	2.0
Transport	17.3	12.7	15.7	11.0	12.2	14.4	13.0	16.1	14.7
IT and other business services	16.9	16.1	16.0	10.1	11.8	6.5	4.0	3.6	8.1
Finance and insurance	4.2	4.7	5.0	2.5	7.6	3.4	2.9	2.8	7.4
Consumer services	1.9	2.5	2.5	1.8	2.3	2.1	1.8	1.9	4.6
Other Services	3.1	4.3	3.4	2.5	12.5	7.3	3.6	4.3	14.4
Total	100	100	100	100	100	100	100	100	100
Total services	**48.8**	**45.3**	**48.0**	**36.2**	**51.3**	**38.0**	**28.3**	**34.4**	**55.1**

Source: GTAP, wiiw calculations.

However, looking at the export structures once we also account for intermediate linkages, we can find that Austria's service intensity of exports is actually not so strong, being at par with the EU13 level. The country outperforms new EU member states and Asian countries, but significantly lags behind Switzerland and NAFTA countries.

Table 2.4

Geographic structure of Austria's foreign trade in the base year, %

	Exports	Imports
Germany	29.6	29.3
Old EU Members	28.0	27.9
New EU Members	12.3	12.4
Switzerland	4.0	4.0
Australia, New Zealand	0.8	0.8
East Asia	4.4	4.4
Southeast Asia	2.2	2.2
South Asia	0.9	0.9
North America	7.1	7.1
Latin America	1.4	1.4
Middle East and North Africa	2.4	2.5
Sub-Saharan Africa	1.1	1.1
Rest of World	5.8	6.0
Total	100.0	100.0

Source: GTAP, wiiw calculations.

Table 2.5

Austria's output structure in the base year, %

Sector	Shares of sectors in total output	Share of exports in output
Agriculture, forestry, fish	1.6	10.0
Energy extraction	0.4	13.5
Petrochemicals	0.7	7.4
Processed food	3.5	29.2
Textiles and clothing	1.2	57.7
Chemicals and plastics	3.3	67.8
Other light manufacturing	7.3	40.2
Metals	4.0	53.2
Motor vehicles	2.9	89.8
Transport equipment	0.8	76.0
Other machinery	7.6	70.3
Utilities	1.5	10.7
Construction	10.1	2.2
Communications	2.2	8.2
Transport	16.4	17.3
IT and other business services	16.5	20.1
Finance and insurance	3.9	16.8
Consumer services	2.2	14.7
Other Services	14.0	3.1
Total	100.0	
Total services	**66.7**	

Source: GTAP, wiiw calculations.

Analysis of the Austria's production structure reveals that services comprise for the bulk of the economy and their share is higher in the production than in exports, even taking into account intermediate linkages. Manufacturing sectors (in particular, motor vehicles, transport equipment, other machinery, and chemicals) have the highest shares of exports in output. (Table 2.5)

While direct exports are informative when exploring trade linkages, ultimately it is the linkages between trade and value added (labor, investment, land and natural resources) that establish a link between trade and the pattern of national income and labor market conditions. To highlight this issue, we next work here with several measures of the sector intensity of Austrian exports. This includes the direct contribution of sectors to Austrian exports measured in terms of the value added content of European exports, as well as indirect shares. Indirect shares are measured in two ways. The first involves forward linkages, where we look at value added within a sector that is embodied, through downstream or forward linkages, in final exports in other sectors. The second involves backward linkages, where we look at value added from upstream sectors that is embodied, through intermediate linkages, in final exports within a particular sector. The forward linkages form of export value added tells us what sectors actually contribute value added to final exports, while the second tells us what sectors serve as a mechanism for exporting value added. The formal definitions are presented in Box 2.1 below.

Box 2.1

The Value Added in Exports

We measure the value added contained in exports as follows. First, we calculate direct cost shares linked to demand for intermediate inputs:

$$\theta_{z,i} = \frac{e_{z,i}}{\sum_j e_{j,i}} \times 100$$

Direct value added in exports:

$$\alpha_z = v_z x_z$$

Total (direct and indirect) value added in exports based on forward linkages:

$$F_z = \alpha_z + \sum_{i \neq z} .01 \times \theta_{z,i} v_z x_i$$

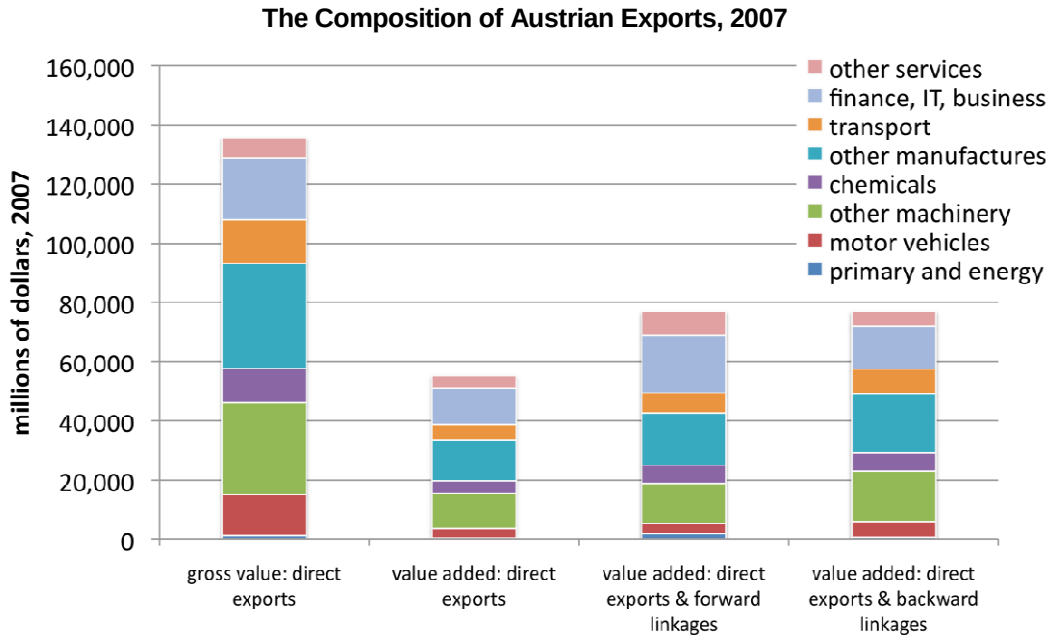
Total (direct and indirect) value added in exports based on backward linkages:

$$B_z = \alpha_z + \sum_{i \neq z} .01 \times \theta_{i,z} v_i x_z$$

where: $e_{i,j}$ represents expenditure in sector j on inputs indexed by i, including both value added or primary inputs (capital, labor, land) and intermediate inputs; v_j represents expenditure on primary inputs as a share of total costs of production in sector j; and x_j represents the gross value of exports from sector j.

The basic pattern of Austria's exports on a sector basis is presented in Figure 2.1 below. The underlying data are the same input-output data used for the modelling as discussed in Section 4. The data summarized in Tables 2.6 and 2.7. The basic message that stands out in the figure and tables is that, while manufacturing is dominant in terms of gross export values, it is less so when we focus on value added. In addition, the gross value of output overstates the share of exports in GDP, as they include imported inputs. This is especially true for heavy machinery and transport equipment production that is integrated with German industry. Indeed, while the gross value of exports was approximately $136 billion in 2007, we estimate that this embodied $77 billion in value added terms. This means that roughly 50% of gross export values, by our estimates, represent value actually originating in Austria.

Figure 2.1



When we focus on forward linkages, the relative importance of sectors changes substantively. In particular, while manufacturing represents almost 70% of exports on a gross output value basis (68% in 2007), when we focus on direct value added this falls to 60%. It falls further, to 53%, when we focus on indirect exports due to intermediate linkages between sectors. Indeed, while on a gross value basis, services represent 31% of Austria's exports, this rises to a full 45% when we focus on direct and indirect value added contained in exports.

The backward linkages data tell a different story. While services are an important input, in terms of value added, into Austrian exports in the manufacturing sector, the backward linkage data tells us which sectors serve as the mechanism for actual exports of value added. Again, manufacturing rises to 70% of export value, though we know from the forward link-

age data that much of this value added is actually services inputs that are contained in the gross value of exports in manufacturing.

Together, these data help highlighting channels through which, in what follows, we can expect to see that changes in demand for manufacturing exports during the recession ultimately feed back into demand for producer services. This means that the drop in demand for transport equipment and heavy investment goods during the recession, as detailed in the following section, will actually be transmitted more widely to the service sector through intermediate linkages.

Table 2.6

Trade Linkages and Value Added, values in 2007

	gross value: direct exports	value added: direct exports	value added: direct exports & forward linkages	value added: direct exports & backward linkages
primary and energy	1,374	558	2,014	802
manufactured goods	91,853	33,045	40,707	48,327
motor vehicles	13,685	3,171	3,301	5,160
other machinery	31,116	11,730	13,665	17,024
chemicals	11,612	4,346	5,977	6,294
other	35,440	13,798	17,763	19,849
services	42,489	21,700	34,314	27,906
transport	14,836	5,199	6,703	8,310
finance, IT, business	20,781	12,427	19,502	14,488
other	6,871	4,074	8,109	5,108
total	135,716	55,304	77,036	77,036

Own calculations based on data from COMTRADE and GTAP.

Table 2.7

Trade Linkages and Value Added, shares of total in 2007

	gross value: direct exports	value added: direct exports	value added: direct exports & forward linkages	value added: direct exports & backward linkages
primary and energy	1.01	1.01	2.61	1.12
manufactured goods	67.68	59.75	52.84	70.32
motor vehicles	10.08	5.73	4.29	9.15
other machinery	22.93	21.21	17.74	24.36
chemicals	8.56	7.86	7.76	8.96
other	26.11	24.95	23.06	27.85
services	31.31	39.24	44.54	28.56
transport	10.93	9.40	8.70	14.31
finance, IT, business	15.31	22.47	25.32	9.48
other	5.06	7.37	10.53	4.76
total	100.00	100.00	100.00	100.00

Own calculations. Shares are based on values from COMTRADE and GTAP.

CHAPTER 3: OVERVIEW OF THE RECESSION

In this chapter we describe the major characteristics of the recent global recession. First we look at the recession in the global dimension, and then take a closer look at the Austrian case.

a. Global economy

Table 3.1 below reports cumulative changes in the economic indicators for the world economy in 2008-2009. During this period, annual global GDP decreased by 0.5%. The economic decline was driven by the fall in investment by 9.2%, in response the collapse in financial markets and a general loss in investor confidence. The fall in merchandise exports was of a similar scope as that of investment, while services exports turned out to be more resilient to crisis, possibly reflecting lower elasticity of demand and counter-cyclical nature of certain services (such as auditing, consultancy, legal services, repair services, technical assistance to governments).

Table 3.1

Cumulative change of annual global indicators in 2008-2009, %

GDP	-0.5
Investment	-9.2
Exports of goods and services	-8.3
Exports of goods	-9.4
Exports of commercial services (excl. government services)	-1.1
Exports of machinery	-11.7
Exports of motor vehicles	-29.6
Exports of other light manufacturing	-16.0

Source: IMF, WTO

Reflecting the financial nature of the original crisis, the greatest trade declines were in durables and investment demand commodities, exports of which decreased most profoundly, reaching almost 30% in the case of motor vehicles.

b. Austrian recession

The Austrian economy, though having not avoided recession, performed better as compared with the rest of EU15: its GDP during 2008-2009 fell cumulatively by 1.8%, which was 2 p.p. smaller than decline of the German GDP, and 1.9 p.p. smaller than the average decline of the EU15 economy (Table 3.2). New EU member states, though being quite heterogenous in terms of economic performance, on average managed to avoid recession, having small positive growth of 1%. Central and Eastern European countries, which are

major trading partners of Austria in the region, turned out to have the most robust economies.

Similar to the global trends, the decline of Austria's GDP was driven by the investment collapse. Investment as measured by gross fixed capital formation fell during 2008-2009 by 5.1%, which was again lower than in Germany or on average in the EU. It is remarkable, that final household consumption growth was positive in Austria, and significantly higher than in Germany or EU12, which also had resilient domestic markets. However, Austria performed much worse than the other EU members in terms of exports, the decline of which was 15.3%, around 3 p.p. bigger than in Germany or the EU15.

Table 3.2

Cumulative change of annual GDP and its components in 2008-2009, %

	AUT	DEU	EU15	EU12
GDP	-1.8	-3.8	-3.7	1.0
Gross fixed capital formation	-5.1	-7.9	-13.2	-9.1
Final household consumption	1.8	0.5	-1.1	0.5
Final government consumption	4.4	5.3	4.7	4.5
Exports of goods and services	-15.3	-12.2	-11.9	-1
Imports of goods and services	-15.2	-6.4	-11.4	-7.5

Source: Eurostat

Analysis of the changes in exports by sectors tells that the biggest contribution to the Austria's exports decline was made by Austria's major exports sectors, i.e., motor vehicles, other machinery, and other light manufacturing (see Table 3.3). These changes are in line with the global exports trends.

Table 3.3

Cumulative change of annual exports by sectors in 2008-2009, %

Sector	Change
Agriculture, forestry, fish	-2.6
Energy extraction	15.4
Petrochemicals	-9.6
Processed Food	0.1
Textiles and Clothing	-17.3
Chemicals and plastics	-0.4
Other light manufacturing	-16.9
Metals	-22.0
Motor Vehicles	-35.6
Transport equipment	-2.2
Other machinery	-17.7
Services	-0.7

Source: UN COMTRADE, OENB

In terms of the geographic structure, Germany and the rest of EU15 made the biggest contribution to the Austria's exports decline. Decrease in exports to EU12 was matching the decline of exports to Germany (-13.1% vs. -13.3%). Exports to the USA and Japan, which account for relatively small shares of the country's exports, were reduced by almost one third. A striking development was increase in the exports to China by 27.4% (Table 3.4).

Table 3.4

Cumulative change of annual exports by trading partners in 2008-2009, %

Partner	Change
Germany	-13.3
EU13	-17.7
EU12	-13.1
Switzerland	-3.1
China	27.4
USA	-32.8
Japan	-31.0

Source: UN COMTRADE

On the employment side, Austria, similarly to Germany and EU12, managed to increase employment during the recession by 1.2% (Table 3.5). However, the country experienced structural shifts inside the employment structure: amount of the skilled labor during 2 years of the recession increased by 9.2%, while the unskilled labor employment was cut by 2%. Similar structural shifts occurred in the whole EU, though being less profound in EU15, and more drastic in EU12.

Table 3.5

Cumulative change of annual employment in 2008-2009, %

	AUT	DEU	EU15	EU12
Total employment	1.2	1.5	-0.8	0.2
Skilled labor (with tertiary education)	9.2	9.8	6.4	11.4
Unskilled labor	-2.0	-3.1	-3.5	-2.7

Source: Eurostat

CHAPTER 4: DECOMPOSITION OF THE RECESSION

In order to dissect recession of the Austrian economy, we employ a multi-region computable general equilibrium (CGE) model that enables us to estimate the combined impacts of the crisis, as implemented through stylized shocks to investment and household demand across major trading partners. We proceed with a brief outline of the model, and our projection scenario. This is followed by a more detailed analysis of elasticities of the Austrian economy and role of different countries and sectors in the Austrian recession. Details on the model are in Annex A: Technical Annex of CGE Model.

a. Model description

Our assessment of the trade-related transmission mechanisms for global demand shocks into the Austrian economy uses a computable general equilibrium model (CGE) of the Austrian economy and major global trading partners. CGE models help answering *what-if* questions by simulating the price, income and substitution effects in equilibrium on markets under different assumptions. Often, for example, they are used to examine trade policy scenarios. Here we use the model to examine how macroeconomic shocks, reflected in global drops in investment and the general level of output, impact on the Austrian economy through the impact on demand, especially for exports of investment related goods. Key features of the model are outlined here.

The General Equilibrium Model[3]

The CGE model employed is based on an extended version of the Francois, van Meijl, and van Tongeren (2005) model. The most important aspects of the model can be summarised as follows:

- It covers global world trade and production
- It allows for scale economies and imperfect competition
- It includes intermediate linkages between sectors
- It allows for trade to impact on capital stocks through investment effects
- It allows for short-run and long-run adjustment in labor markets

Key features of the model

Model simulations are based on a multi-region global CGE model. Sectors are linked through intermediate input coefficients (based on national social accounts data) as well as

[3] For more technical description of the model see Appendix A.

competition in primary factor markets. The model includes imperfect competition, short-run and long-run macroeconomic closure options, as well as the standard static, perfect competition, Armington-type of model as a subset. It also allows alternative labour market closures. To examine recession, we work with a short-run version of the model. Labor markers are modelled with unemployment and sticky wages, while industry structure (number of varieties and allocation of capital stock across industries) is fixed. With these features in place, we introduce demand shocks (changes) to global investment demand calibrated from actual investment demand changes from 2007-2009. We also calibrate an output shocks based on actual changes in GDP from 2007-2009.

In the model there is a single representative composite household in each region, with expenditures allocated over personal consumption and savings. The composite household owns endowments of the factors of production and receives income by selling these factors to firms. It also receives income from tariff revenue and rents accruing from import/export quota licenses. Part of the income is distributed as subsidy payments to some sectors, primarily in agriculture.

Taxes are included at several levels. Production taxes are placed on intermediate or primary inputs, or on output. Tariffs are levied at the border. Additional internal taxes are placed on domestic or imported intermediate inputs, and may be applied at differential rates that discriminate against imports. Where relevant, taxes are also placed on exports, and on primary factor income. Finally, where relevant (as indicated by social accounting data) taxes are placed on final consumption, and can be applied differentially to consumption of domestic and imported goods.

On the production side, in all sectors, firms employ domestic production factors (capital, labour and land) and intermediate inputs from domestic and foreign sources to produce outputs in the most cost-efficient way that technology allow. Perfect competition is assumed in the agricultural sectors (but the processed food products sector is characterised by increasing returns to scale). In these sectors, products from different regions are assumed to be imperfect substitutes.

Data used for the recession decomposition

The model runs on the GTAP database, version 8. It provides the data for the empirical implementation of the model. The database is the best and most up-to-date source of internally consistent data on production, consumption and international trade by country and sector.[4] The database for the model is benchmarked for 2007. From the 2007 baseline, we then examine how short-run changes in investment demand and output are transmitted to the Austrian economy.

[4] For more information, please refer to Dimaran and McDougall (2006).

The GTAP data on protection incorporate the Macmaps data set, which includes a set of *ad valorem equivalents* (AVEs) of border protection across the world. The source information concerns various instruments, such as specific tariffs, mixed tariffs and quotas, which cannot be directly compared or summed. In order to be of use in a CGE model, these have been converted into an AVE per sector, per country and per trading partner.[5]

Sector aggregation

For the purpose of this study, we aggregate the GTAP database into 19 sectors. The sector structure is shown in Table 4.1.

Table 4.1

Model Sectoring Scheme

Sector	Acronym used	Share in the global exports, %
Agriculture, forestry, fish	1 agf	2.4
Energy extraction	2 egy	7.2
Petrochemicals	3 p_c	2.0
Processed food	4 prf	4.5
Textiles and clothing	5 txc	4.6
Chemicals and plastics	6 crp	11.6
Other light manufacturing	7 olt	7.4
Metals	8 met	6.8
Motor vehicles	9 mvh	8.6
Transport equipment	10 teq	2.5
Other machinery	11 omc	24.6
Utilities	12 uti	0.4
Construction	13 cns	0.4
Communications	14 com	0.6
Transport	15 tsp	6.4
IT and other business servs	16 itb	5.3
Finance and insurance	17 fis	1.9
Consumer services	18 ros	1.1
Other Services	19 OthServices	1.7
Total		100.0

Source: GTAP

The GTAP agricultural and food processing sectors are classified according to the Central Product Classification (CPC). The other GTAP sectors are defined by reference to the International Standard Industry Classification (ISIC rev.3 as defined by United Nations Statistic Division). Services and utility classifications predate the GATS and are based on IMF balance of payments statistics (BOP) and UN definitions.

[5] The MacMaps database is the result of a joint effort by the International Trade Center (governed by UNCTAD and WTO) and Cepii.

Country Aggregation

We work with two regional aggregations of the data. One includes just Austria and the rest of world. The second involves 14 regions, as detailed below in Table 4.2

Table 4.2

Regional Aggregation Scheme

	Acronym used	Share in the global GDP	Share in the global 'exports
Austria	1 aut	0.7	1.3
Germany	2 deu	6.5	9.1
Old EU Members	3 e13	22.3	26.1
New EU Members	4 e12	1.7	3.1
Switzerland	5 che	0.9	1.6
Australia, New Zealand	6 oce	1.7	1.4
East Asia	7 eas	18.6	19.1
Southeast Asia	8 sea	1.9	6.0
South Asia	9 sas	2.1	1.4
North America	10 nam	31.9	15.6
Latin America	11 sam	3.8	3.5
Middle East and North Africa	12 men	2.4	4.5
Sub-Saharan Africa	13 ssa	1.4	1.9
Rest of World	14 row	4.0	5.3
Total		100.0	100.0

Source: GTAP

Macroeconomic closure under recession

To examine recession, we work with a short-run version of the model. In particular, we implement the following additional structural changes to the basic model.

- Labor markers are modelled with unemployment and sticky wages in North America, Japan, and Europe.
- Industry structure, meaning the number of varieties and the allocation of capital stock across industries, is held fixed in the short-run.

With these features in place, we introduce demand shocks (changes) to global investment demand calibrated from actual investment demand changes from 2007-2009. We also calibrate an output shocks based on actual changes in GDP from 2007-2009. In the model, the drop in investment demand during the recession is mapped as a diversion of financial capital away from physical investment (there is a drop in the share of financial savings allocated to physical investment expenditures). The soft labor market closure reflects the short-run sensitivity of employment to firm demand conditions and existing wage structures. The drop in total output, above that following from the investment shock, is modelled as a shock to total macroeconomic output. The allocation of capital within sectors reflects

the realistic assumption that, over the time horizon of one or two years, inter-sector mobility of capital stocks is highly limited.

b. Elasticities of the Austrian economy

In this section we present elasticities of a set of Austria's economic indicators to changes in sectoral exports and GDPs of major trading partners. We calculate elasticities by subjecting the Austrian economy to a 1% decrease in a given sector's exports or a given trading partner's GDP. Exports elasticities are calculated for the short-run perspective – assuming sticky wages in the economy. The results are presented in Tables 4.3 and 4.4. They should be read as follows: how much (in %) indicators in the columns change as a reaction to 1% decrease in sectoral exports or GDPs of the major trading partners (listed in rows).

Among the sectors analyzed, it's changes in other machinery exports, which cause the highest impact on the Austria's GDP – machinery exports elasticity of the GDP is twice higher than motor vehicles or other light manufacturing ones (0.08% vs. 0.04%). Transports export elasticity of GDP is only slightly higher than that of IT and other business services (0.05% vs. 0.04%).

Output of sectors, which experience an export shock, changes proportionately to shares of exports in their output.

Demand for labor has on average higher exports elasticity than GDP (apparently due to sluggishness of labor reallocations in the short run). Only in other machinery and IT and other business services exports shock causes higher change in the demand for skilled labor than in the demand for unskilled one. Motor vehicles shock causes equal change in the demand for skilled and unskilled labor.

Table 4.3

Export elasticities of the Austrian economy, %

Exports sectors	GDP	Output of the sector experiencing exports shock	Demand for skilled labor	Demand for unskilled labor
Other machinery	-0.08	-0.65	-0.15	-0.14
Motor vehicles	-0.04	-0.89	-0.05	-0.05
Other light manufacturing	-0.04	-0.39	-0.07	-0.08
Transports	-0.05	-0.20	-0.08	-0.09
IT and other business services	-0.04	-0.14	-0.11	-0.06

Source: GTAP, wiiw calculations

External demand elasticities of the Austrian economy are quite predictably proportional to the shares of the country's trading partners in total exports. Austrian economy responds the most to the shock coming from the fall of Germany's GDP, with EU13 demand elastic-

ity lagging behind only by 0.01%. The same relation holds for labor demand elasticities. It is noteworthy that external demand elasticity of the demand for skilled labor is higher than that of unskilled labor in the case of Germany and EU12, while in the case of EU13 the demand for unskilled labor reacts relatively stronger.

Table 4.4

External demand elasticities of the Austrian economy (with respect to changes in trading partners' GDP), %

Trading partner	GDP	Demand for skilled labor	Demand for unskilled labor
Germany	-0.08	-0.14	-0.13
EU13	-0.07	-0.11	-0.13
EU12	-0.03	-0.05	-0.04

Source: GTAP, wiiw calculations

c. Transmission of external output / demand and investment shocks to Austria

Table 4.5 presents an overview of the scenarios we simulate in the CGE-model, based on the actual recession data, cumulative for 2008-2009. We want to see what the role of different sectors and trading partners was in shaping the Austrian recession. Of course, the effects of the recession components we attempt to estimate need not sum up to the total recession pattern, since their interaction would yield additional shifts in the economy. However, the simulations would still let us judge about the relative importance of given shock components for the Austrian economic downturn.

Table 4.5

Simulations scenarios

	Trading partners' recession	
Scenarios \ Indicators	GDP, % change	Investment, % change
Global recession	-0.5	-9.2
Germany	-3.8	-7.9
EU13	-4.0	-13.2
EU12	1.0	-9.1
Switzerland	0.0	-4.4
North America	-4.6	-18.2
	Global import demand drop	
	% change	
Machinery	-11.7	
Vehicles	-29.6	
Other light manufacturing	-16.0	
Transports*	-10	
IT and other business services*	-10	

* Our assumption

Source: Eurostat, IMF, UN COMTRADE, World Bank, WTO

As our simulations show, EU13 contributed the most to the Austria's GDP fall among its trading partners (Table 4.6). It is noteworthy that Germany, which accounts for practically the same share of Austrian exports and experienced almost the same rate of GDP decline, has much lower negative impact on the Austrian GDP. A possible reason for this can be much stronger decline in investment in EU13 as compared with Germany (-13.2% vs. -7.9%), which affected Austrian exports, dominated by investment demand goods, more heavily. EU13 demand fall also had much more severe effect on the demand for labor as compared with Germany: the decline of the demand for unskilled labor was twice higher, while for skilled labor the ratio was almost one to four.

EU12's effect on the Austrian economy during the crisis was close to zero, thus as expected, they rather cushioned the country from the crisis.

Table 4.6

Results of simulations: GDP and demand for labor

Scenarios \ Indicators	GDP	Demand for skilled labor	Demand for unskilled labor
Global recession	-2.1	-3.3	-4.0
DEU	-0.4	-0.7	-0.6
EU13	-1.0	-2.7	-1.3
EU12	-0.1	-0.1	-0.1
Machinery	-2.3	-4.1	-3.8
Motor vehicles	-1.0	-1.4	-1.5
Other light manufacturing	-0.7	-1.1	-1.3
Transports	-0.4	-0.6	-0.7
IT and other business services	-0.3	-0.9	-0.4

Source: GTAP, wiiw calculations

From the sectoral demand perspective, the biggest impact on the Austrian economy was the fall in the global demand for machinery. The fall was so severe, that it alone could cause a decline in Austria's GDP of the scale comparable to one actually brought about by the global recession. Machinery is followed by motor vehicles in terms of the scale of impact on GDP and demand for labor. Services sectors appear to have been causing less damage to the Austrian economy as compared with manufacturing.

The fall in the demand for skilled labor in the sectoral scenarios outpaces the rate of GDP decline for all the sectors. The most dramatic fall occurs due to the machinery sector, the lowest layoffs occur in transports. The demand for skilled labor falls faster than the demand for unskilled one in machinery and IT and other business services.

A look at the changes in sectoral output of Austria under different scenarios sheds additional light on the results. As Table 4.7 shows, it is EU13 region, which causes most noticeable changes in the country's production, though affecting primarily not major export

sectors of Austria. This together with significant drop in the output of financial and insurance services further confirms that it is non-trade transmission channels, which play the most important role in the case of EU13 impact on the Austrian economy during the recession.

Sectoral demand scenarios cause the biggest changes in the production of services sectors, which appear to have high intermediate service linkages. On the contrary, drop of demand for transport and IT and other business services does not have much impact on manufacturing (apart from petrochemicals in the transports case), thus suggesting that services have primarily upward linkages to manufacturing sectors (i.e., services are rather used as inputs to manufacturing, while manufacturing inputs in services sectors are small).

Table 4.7

Results of simulations: sectoral output, % change

Sector	Global recession	DEU	EU13	EU12	omc	mvh	olt	tsp	itb
Agriculture, forestry, fish	0.4	-0.5	-6.5	-0.4	-0.5	-0.3	-0.3	-0.1	0.0
Energy extraction	-1.0	0.0	4.6	0.3	0.0	0.1	0.0	0.1	-0.1
Petrochemicals	-0.9	-0.4	-1.9	-0.2	-1.4	-0.7	-0.5	-0.7	-0.1
Processed food	0.2	-0.8	-9.4	-0.4	-1.1	-0.5	-0.1	-0.2	0.0
Textiles and clothing	0.9	-0.1	-14.5	-0.1	-0.2	0.0	0.3	0.1	0.3
Chemicals and plastics	-0.3	-0.2	-21.0	-0.3	0.8	0.6	0.4	0.3	0.5
Other light manufacturing	-1.2	-0.4	-8.4	-0.9	0.0	-0.1	-5.7	0.1	0.3
Metals	-3.8	0.3	-3.0	-0.1	2.3	1.1	0.4	0.3	0.4
Motor vehicles	-1.3	-0.8	0.9	-0.4	0.9	-25.4	0.2	0.1	0.3
Transport equipment	-2.4	1.6	3.0	0.7	2.7	0.8	0.4	0.3	0.8
Other machinery	-3.6	0.4	0.0	0.2	-15.7	0.5	0.3	0.3	0.7
Utilities	-0.8	-0.8	-5.8	-0.9	-0.8	-0.4	-0.5	-0.2	-0.1
Construction	-6.3	0.3	23.9	0.7	-1.6	-0.7	-0.2	-0.1	-0.2
Communications	-1.1	-0.6	-3.6	-0.1	-2.1	-0.8	-0.5	-0.4	-0.2
Transport	-1.0	-0.4	-1.8	0.0	-2.0	-0.7	-0.6	-1.9	0.0
IT and other business servs	-0.8	-0.6	-6.0	-0.1	-0.6	-0.3	-0.2	-0.1	-1.3
Finance and insurance	-0.6	-0.8	-7.6	-0.1	-1.3	-0.5	-0.3	-0.3	0.1
Consumer services	-1.3	-0.8	-3.8	-0.2	-1.9	-0.8	-0.8	-0.2	-0.2
Other Services	-2.6	-0.6	-1.0	0.0	-3.4	-1.5	-1.0	-0.6	-0.7

Source: GTAP, wiiw calculations

d. Discussion

The recent recession has been accompanied by dramatic changes in trade. For Austria, this has involved strong pressure on manufacturing sectors linked closely to its EU partners, and especially to Germany. As EU manufacturing has cycled through export collapse (and now recovery), this has translated into impacts on linked industries in Austria as well. Though it did not avoid recession, the Austrian economy performed better than the many of the EU15. Its GDP during 2008-2009 fell cumulatively by 1.8%, which was a full 2 per-

centage points smaller than the decline in GDP of its major trading partner Germany. It was also 1.9 percentage points smaller than the average decline across the EU15. Though a heterogeneous group, the new EU Member States (important trading partners for Austria), actually had small but positive cumulative growth over the same period.

While the drop in global demand was very strongly focused on the sectors producing heavy investment goods, the actual pressure this placed on the Austrian economy also hinged on the linkages of these sectors to other elements of the Austrian economy. On a value added basis, drop for demand in these heavy industrial sectors placed negative pressure on sectors less exposed to the direct vagaries of the world economy. The Austrian value added in these sectors includes a substantial share of producer services (IT, professional services, finance, and other business services). Indeed, we have shown that a great deal of the value added contained in Austrian manufacturing exports comes from service inputs. As such, though the recession featured a disproportionate drop in global demand for heavy industrial and investment goods, in the Austrian context demand shocks in goods will ultimately place pressure on producer services as well.

ANNEX A – Technical overview of the CGE Model

B.1. Introduction

The core CGE model is based on the assumption of optimizing behaviour on the part of consumers, producers, and government. Consumers maximize utility subject to a budget constraint, and producers maximize profits by combining intermediate inputs and primary factors at least possible cost, for a given technology. The model employed here is based on Francois, van Meijl, and van Tongeren (2005) model (the FMT model). The FMT model is a standard, multi-region computable general equilibrium (CGE) model, with important features related to the structure of competition (as described by Francois and Roland-Holst 1997). Imperfect competition features are described in detail in Francois (1998). Social accounting data are based on the most recent Version 7.1 of the GTAP dataset (www.gtap.org). It includes 16 regions and 32 sectors. The full computer code for the FMT model can be downloaded from this link:
http://www.i4ide.org/people/~francois/data/DohaModel.zip

The model is implemented in GEMPACK, a software package designed for solving large applied general equilibrium models6. The model is solved as an explicit non-linear system of equations, through techniques described by Harrison and Pearson (1994). More information can be obtained http://www.monash.edu.au/policy/gempack.htm. For a detailed discussion of the basic algebraic model structure represented by the GEMPACK code, refer to Hertel (1996). This appendix provides a broad overview of the model and detailed discussion of mathematical structure is limited to added features, while the standard GTAP structure is covered in Hertel (1996).

B.2. General structure

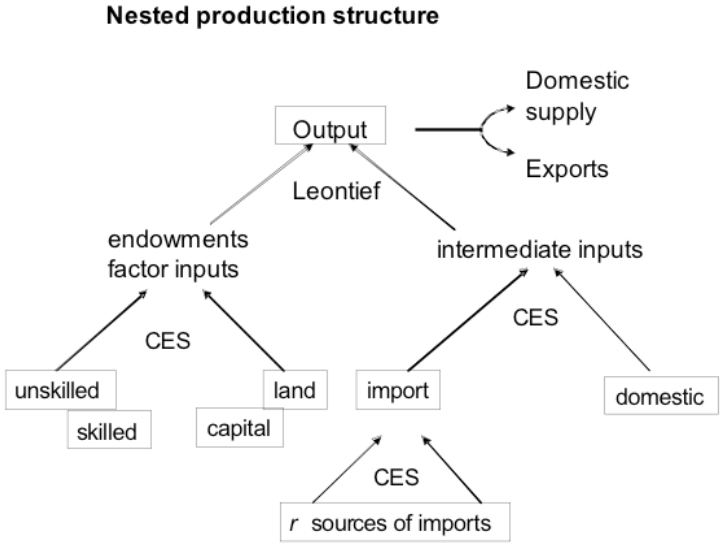
The general conceptual structure of a regional economy in the model is as follows: firms produce output, employing land, labour, capital, and natural resources and combine these with intermediate inputs, within each region/country. Firm output is purchased by consumers, government, the investment sector, and by other firms. Firm output can also be sold for export. Land is only employed in the agricultural sectors, while capital and labour (both skilled and unskilled) are mobile between all production sectors. While capital is assumed to be fully mobile within regions, land, labour and natural resources are not.

All demand sources combine imports with domestic goods to produce a composite good. In constant returns sectors, these are Armington composites. In increasing returns sectors, these are composites of firm-differentiated goods. Relevant substitution and trade elasticities are available in Table B.1. The production and consumption structure of the CGE model can be best understood by using a technology tree as shown in Figure B.1.

[6] The result of our analysis can be downloaded and replicated our results, but the user will need access to GEMPACK, in order to make modifications to the code or data.

Figure B.1

The Basic Production Flows in the Model



B.3 Taxes and policy variables

Taxes are included in the theory of the model at several levels. Production taxes are either placed on intermediate or primary inputs, or on output. Some trade taxes are modeled at the border. There are also additional internal taxes that can be placed on domestic or imported intermediate inputs, and may be applied at differential rates that discriminate against imports. Where relevant, taxes are also placed on exports, and on primary factor income. Finally, where indicated by social accounting data as being relevant, taxes are placed on final consumption, and can be applied differentially to consumption of domestic and imported goods.

Trade policy instruments are represented as import or export taxes/subsidies. This includes applied most-favoured nation (MFN) tariffs, antidumping duties, countervailing duties, price undertakings, export quotas, and other trade restrictions. The major exception is service-sector trading costs, which are discussed in the next section. The full set of tariff vectors are based on WTO tariff schedules, combined with possible Doha and regional initiatives as specified by the Commission during this project, augmented with data on trade preferences. The set up of services trade barrier estimates is described below.

B.4. Trade and transportation costs

International trade is modeled as a process that explicitly involves trading costs, which include both trade and transportation services. These trading costs reflect the transaction costs involved in international trade, as well as the costs of the physical activity of transpor-

tation itself. Those trading costs related to international movement of goods and related logistic services are met by composite services purchased from a global trade services sector, where the composite "international trade services" activity is produced as a Cobb-Douglas composite of regional exports of trade and transport service exports. Trade-cost margins are based on reconciled f.o.b. and c.i.f. trade data, as reported in version 7 of the GTAP dataset.

B.5. The composite household and final demand structure

Final demand is determined by an upper-tier Cobb-Douglas preference function, which allocates income in fixed shares to current consumption, investment, and government services. This yields a fixed savings rate. Government services are produced by a Leontief technology, with household/government transfers being endogenous. The lower-tier nest for current consumption is specified as a Constant-difference elasticity (CDE) functional form, as parameterized in the core GTAP database. This allows for shifts in demand shares linked to non-homothetic consumer preferences. The regional capital markets adjust so that changes in savings match changes in regional investment expenditures[7].

B.6. Demand for Imports

The basic structure of demand is based on CES (Armington) preferences. While the model also includes features linked to firm level product differentiation, for the purpose of long-run macroeconomic projections with endogenous TFP and capital accumulation, we follow a relatively standard approach and implement national product differentiation. Goods are differentiated by country of origin, and the similarity of goods from different regions is measured by the elasticity of substitution. Formally, within a particular region, we assume that demand for goods from different regions is aggregated into a composite import according to the following CES function, where α is a CES preference weight:

$$(1) \qquad q^{M}_{j,r} = \left[\sum_{i=1}^{R} \alpha_{j,i,r} M^{\rho_j}_{j,i,r} \right]^{1/\rho_j}$$

In equation (1), $M_{j,i,r}$ is the quantity of imports in sector j from region *i* consumed in region *r*. The elasticity of substitution between varieties from different regions is then equal to σ^{M}_{j}, where $\sigma^{M}_{j}=1/(1-\rho_j)$. Composite imports are combined with the domestic good q^{D} in a second CES nest, yielding the Armington composite *q*.

$$(2) \qquad q_{j,r} = \left[\Omega_{j.M.r} \left(q^{M}_{j,r} \right)^{\beta_j} + \Omega_{j,D,r} \left(q^{D}_{j,r} \right)^{\beta_j} \right]^{1/\beta_j}$$

[7] Note that the Cobb-Douglas demand function is a special case of the CDE demand function employed in the standard GTAP model code. It is implemented through GEMPACK parameter files.

The elasticity of substitution between the domestic good and composite imports is then equal to σ^D_j, where $\sigma^D_j=1/(1-\beta_j)$. At the same time, from the first order conditions, the demand for import $M_{j,i,r}$ can then be shown to equal

$$
\begin{aligned}
M_{j,i,r} &= \left[\frac{\alpha_{j,i,r}}{P_{j,i,r}}\right]^{\sigma_i^m} \left[\sum_{i=1}^{R} \alpha_{j,i,r}^{\sigma_j^M} P_{j,i,r}^{1-\sigma_j^M}\right]^{-1} E_{j,r}^M \\
&= \left[\frac{\alpha_{j,i,r}}{P_{j,i,r}}\right]^{\sigma_j^M} \left(P_{j,r}^M\right)^{\sigma_j^M - 1} E_{j,r}^M
\end{aligned}
\tag{3}
$$

where $E^M_{j,r}$ represents expenditures on imports in region *r* on the sector *j* Armington composite, and $P_{j,r}$ denotes aggregate prices levels within an import country, while $P_{j,l,r}$ denotes a bilateral import price. In practice, the two nests can be collapsed, so that imports compete directly with each other and with the corresponding domestic product. This implies that the substitution elasticities in equations (2) and (3) are equal.

ANNEX B – Mapping of Model Sectors to NACE and GTAP Sectors

Table B.1

Mapping of Model Sectors to NACE and GTAP Sectors

CGE Model Sectors	NACE sectors	GTAP sectors
1 Agriculture, forestry, fish	11 Growing of crops; market gardeninig; horticulture	1 PDR - Paddy rice
		2 WHT - Wheat
		3 GRO - Cereal grains n.e.c.
		4 V_F - Vegetables, fruit, nuts
		5 OSD - Oil seeds
		6 C_B - Sugar cane, sugar beet
		7 PFB - Plant-based fibers
		8 OCR - Crops n.e.c.
	12 Farming of animals	9 CTL - Bovine cattle, sheep and goats, horses
		10 OAP - Animal products n.e.c.
		11 MLK - Raw milk
		12 WOL - Wool, silk-worm cocoons
	20 Forestry, logging and related sevices aktivities	13 FRS - Forestry
	50 Fishing, operation of fish hatcheries and fish farms	14 FSH - Fishing
2 Energy extraction	101 Anthracite,not agglomrtd	15 COA - Coal
	101 Bitum.coal not agglomrtd	16 OIL - Oil
	101 Oth coal,not agglomerat.	17 GAS - Gas
	101 Briquettes etc (coal)	18 part OMN - Minerals n.e.c.
	102 Lignite,not agglomerated	
	102 Lignite,agglomerated	
	103 Peat	
	111 Extraction of crude petroleum and natural gas	
	120 Mining of uranium and thorium ores	
	131 Mining of iron metals	
	132 Mining of non-ferrous metal ores, exept uranium and thorium ores	
	141 Quarrying of stone	
	142 Quarrying of sand and clay	
	143 Mining of chemical and fertilizer minerals	
	144 Production of salt	
	145 Other mining and quarrying n.e.c.	
3 Petrochemicals	231 Coke oven products	32 P_C - Petroleum, coal products
	232 Refined petroleum and nuclear fuel	
	233 Nuclear fuel	
4 Processed Foods	151 Meat products	19 CMT - Bovine meat prods
	152 Fish and fish products	20 OMT - Meat products n.e.c.
	153 Fruits and vegetables	21 VOL - Vegetable oils and fats
	154 Vegetable and animal oils and fats	22 MIL - Dairy products

CGE Model Sectors	NACE sectors	GTAP sectors
	155 Dairy products; ice cream	23 PCR - Processed rice
	156 Grain mill products and starches	24 SGR - Sugar
	157 Prepared animal feeds	25 OFD - Food products n.e.c.
	158 Other food products	26 part B_T - Beverages and tobacco products
	160 Tobacco products	26 part B_T - Beverages and tobacco products
5 Textiles and clothing	171 Preparation and spinning of textile fibre	27 TEX - Textiles
	172 Textile weaving	28 WAP - Clothing
	173 Finishing of textiles	
	174 Made-up textile articles	
	175 Other textiles	
	176 Knitted and crocheted fabrics	
	177 Jerseys/pullovers/etc	
	181 Leather clothes	
	182 Other wearing apparel and accessories	
	183 Dressing and dyeing of fur; articles of fur	
6 Chemicals and plastics	241 Basic chemicals	33 part CRP - Chemical, rubber, plastic products
	242 Pesticides, other agro-chemical products	
	243 Paints, coatings, printing ink	
	244 Pharmaceuticals	
	245 Detergents, cleaning and polishing, perfumes	
	246 Other chemical products	
	251 Rubber products	
	252 Plastic products	
7 Other light manufacturing	191 Tanning and dressing of leather	29 LEA - Leather products
	192 Luggage, handbags, saddlery and harness	30 LUM - Wood products
	193 Footwear	31 part PPP - Paper products, publishing
	201 Sawmilling, planing and impregnation of wood	34 NMM - Mineral products n.e.c.
	202 Panels and boards of wood	42 OMF - Manufactures n.e.c.
	203 Builders' carpentry and joinery	
	204 Wooden containers	
	205 Other products of wood; articles of cork, etc.	
	211 Pulp, paper and paperboard	
	212 Articles of paper and paperboard	
	221 Publishing	
	222 Printing	
	261 Glass and glass products	
	262 Ceramic goods	
	263 Ceramic tiles and flags	
	264 Bricks, tiles and construction products	
	265 Cement, lime and plaster	
	266 Articles of concret, plaster and cement	
	267 Cutting, shaping, finishing of stone	
	268 Other non-metallic mineral products	
	361 Manufacture of furniture	

CGE Model Sectors	NACE sectors	GTAP sectors
	362 Jewellery and related articles 363 Musical instruments 364 Sports goods 365 Games and toys 366 Miscellaneous manufacturing n. e. c. 371 Recycling of metal waste and scrap 372 Recycling of non-metal waste and scrap	
8 Metals	271 Basic iron and steel, ferro-alloys (ECSC) 272 Tubes 273 Other first processing of iron and steel 274 Basic precious and non-ferrous metals 281 Structural metal products 282 Tanks, reservoirs, central heating radiators and boilers 283 Steam generators 284 Forging, pressing, stamping and roll forming of metal; powder metallurgy 285 Treatment and coating of metals; general mechanical engineering 286 Cutlery, tools and general hardware 287 Other fabricated metal products	35 I_S - Ferrous metals 36 NFM - Metals n.e.c. 37 FMP - Metal products
9 Motor vehicles	341 Motor vehicles 342 Bodies for motor vehicles, trailers 343 Parts and accessories for motor vehicles	38 MVH - Motor vehicules and parts
10 Other transport equipment	351 Ships and boats 352 Railway locomotives and rolling stock 353 Aircraft and spacecraft 354 Motorcycles and bicycles 355 Other transport equipment n. e. c.	39 OTN - Transport equipment n.e.c.
20 Other machinery	321 Electronic valves and tubes, other electronic comp. 322 TV, and radio transmitters, apparatus for line telephony 323 TV, radio and recording apparatus 300 Office machinery and computers 291 Machinery for production, use of mech. power 292 Other general purpose machinery 293 Agricultural and forestry machinery 294 Machine-tools 295 Other special purpose machinery 296 Weapons and ammunition 297 Domestic appliances n. e. c.	40 ELE - Electronic equipment 41 OME - Machinery and equipment n.e.c.

CGE Model Sectors	NACE sectors	GTAP sectors
	311 Electric motors, generators and transformers	
	312 Electricity distribution and control apparatus	
	313 Isolated wire and cable	
	314 Accumulators, primary cells and primary batteries	
	315 Lighting equipment and electric lamps	
	316 Electrical equipment n. e. c.	
	331 Medical equipment	
	332 Instruments for measuring, checking, testing, navigating	
	333 Manufacture of industrial process control equipment	
	334 Optical instruments and photographic equipment	
	335 Watches and clocks	
22 Utilities	401 Electricity, gas, steam and hot water supply	43 ELY -Production, collection and distribution of electricity
	402 Manufacture of gas; distribution of gaseous fuels through mains	44 GDT - Manufacture of gas; distribution of gaseous fuels through mains
	403 Steam and hot water supply	
	410 Collection, purification and distribution of water	45 WTR - Collection, purification and distribution of water
23 Construction	450 Construction	46 CNS - Construction
24 Trade	500 repair of motor vehicles and motorcycles; retail	47 TRD - trade and distribution services
	510 Wholesale trade and commission trade, except of motor vehicles an	
	521 Non-specialized retail trade in stores	
	522 Retail sale of food, beverages and tobacco in specialized stores	
	523 Other retail trade of new goods in specializ	
	524 Retail sale of second-hand goods in stores	
	525 Retail trade not in stores	
	526 Repair of household and personal goods	
	550 Hotels and restaurants	
25 Transport	600 Supporting and auxiliary transport activities; activities of travel agencies	48 OTP - other transport
	630 Land transport; transport via pipelines	
	610 Water transport	49 WTP - water transport
	620 Air transport	50 ATP - air transport
26 Communications	640 Post and communications	51 CMN - communications
27 Financial services	650 Financial intermediation, except insurance and pension funding	52 OFI - other financial services
	670 Activities auxiliary to financial intermediation	
28 Insurance	660 Insurance and pension funding, except compulsory social security	53 ISR - insurance
29 Other business services	700 Real estate activities	54 OBS - other business services
	711 Renting of transport equipment	

CGE Model Sectors		NACE sectors		GTAP sectors	
		712	Renting of other machinery and equipment		
		713	Renting of personal and household goods nec		
		720	Computer and related activities		
		730	Research and development		
		740	Other business activities		
30	Recreational and other consumer services	920	Recreational, sporting, and cultural activities	55	ROS - recreational and other consumer services
		930	Other service activities		
		950	Private households with employed persons		
31	Other services	750	Public administration and defense; compulsory social security	56	OSG - public services
		800	Education		
		850	Health and social work		
		900	Sewage and refuse disposal, sanitation and similar activities		
		910	Activities of membership organizations n.e.c.		
		990	Extra-territorial organizations and bodies		
		n.a.	n.a.	57	DWE - dwellings

References

Bénassy-Quéré, A., Y. Decreux , L. Fontagné, D. Khoudour-Castéras (2009), “Explaining the steep drop in international trade with mirage,” CEPII working paper.

Christie, E., J.F. Francois, M. Holzner, S. Leitner, O. Pindyuk (2009a), “AUSTRIA 2020: The impact of medium-term global trends on the Austrian economy,” report prepared for the Austrian FIW – Research Centre International Economics.

Christie, E., J.F. Francois, W. Urban and F. Wirl (2009b), “China’s Foreign Oil Policy Genesis, Deployment and Selected Effects,” A study commissioned by the Austrian Federal Ministry of Economy, Family and Youth (BMWFJ) within the scope of the Research Centre International Economics (FIW) and funded out of the Internationalisation Program “go international,” wiiw: Vienna.

Dimaran, B, and McDougall, R., ed. (2007), The GTAP database - version 7, Global Trade Analysis Center: Purdue University.

Francois, J.F., B. McDonald and H. Nordstrom (1996), "Trade liberalization and the capital stock in the GTAP model," GTAP consortium technical paper

Francois, J., H. van Meijl and F. van Tongeren (2005), “The Doha Round and Developing Countries,” Economic Policy.

Francois, J., O. Pindyuk, and J. Woerz (2008), “International Transactions in Services: Data on International Trade and FDI in the Service Sectors,” Institute for International and Development Economics.

Francois, J., Reinert, K. A. (1996), “The Role of Services in the Structure of Production and Trade: Stylized Facts from a Cross-Country Analysis”, Asia-Pacific Economic Review, Vol. 2(1), May.

Francois, J. and G. Wignarajan (2008), “Economic Implications of Asian Integration,” Global Economy Journal.

Freund, Caroline (2009), “The Trade Response to Global Downturns. Historical Evidence,” World Bank Working Papers 5015, August 2009.

Harrison, W.J. & K.R. Pearson, (1994). "Computing Solutions for Large General Equilibrium Models Using GEMPACK," Centre of Policy Studies/IMPACT Centre, Melbourne University.

Hertel, T., M. Ivanic, P. Preckel, and J. Cranfield. (2004) “Poverty Impacts of Multilateral Trade Liberalization.” World Bank Economic Review 18(2), 205-236.

McKibbin, W.J., and A. Stoeckel, (2009), “Modeling the Global Financial Crisis. Centre for Applied Macroeconomic Analysis,” The Australian National University, Working Paper 25/2009.

Reinert, K.A. and D.W. Roland-Holst (1994), ‘Structural Change in the United States: Social Accounting Estimates for 1982–1988’, Empirical Economics, 19:3, 429–49.

Reinert, K.A. and D.W. Roland-Holst, (1997), “Social Accounting Matrices,” in J.F. Francois and K.A. Reinert, eds., Applied Methods for Trade Policy Analysis: A Handbook, Cambridge University Press.

Robinson, S. (1989), ‘Multisectoral Models’, in H.B. Chenery and T.N. Srinivasan (eds.), Handbook of Development Economics, North Holland, Amsterdam, 885–947.

Willenbockel, Dirk; Robinson, Sherman (2009), “The Global Financial Crisis, LDC Exports and Welfare: Analysis with a World Trade Model,” Munich Personal RePEc Archive Working Paper No. 15377, April.Antweiller, W. and D. Trefler (2002), “Increasing Returns and All That: A View from Trade,” *American Economic Review*, 96: March.