

Middlesex University Research Repository:

an open access repository of
Middlesex University research

<http://eprints.mdx.ac.uk>

Wu, Yinghong, 2011. Economic impacts of different skilled levels of immigration labour: a CGE assessment for the UK. Available from Middlesex University's Research Repository.

Copyright:

Middlesex University Research Repository makes the University's research available electronically.

Copyright and moral rights to this thesis/research project are retained by the author and/or other copyright owners. The work is supplied on the understanding that any use for commercial gain is strictly forbidden. A copy may be downloaded for personal, non-commercial, research or study without prior permission and without charge. Any use of the thesis/research project for private study or research must be properly acknowledged with reference to the work's full bibliographic details.

This thesis/research project may not be reproduced in any format or medium, or extensive quotations taken from it, or its content changed in any way, without first obtaining permission in writing from the copyright holder(s).

If you believe that any material held in the repository infringes copyright law, please contact the Repository Team at Middlesex University via the following email address:

eprints@mdx.ac.uk

The item will be removed from the repository while any claim is being investigated.

**Economic Impacts of Different Skilled
Levels of Immigration Labour: A CGE
Assessment for the UK**

**By
Yinghong WU**

**Thesis submitted to Middlesex University for the
Degree of Doctor of Philosophy**

December 2011

Acknowledgements

First and foremost, I would like to express my utmost gratitude and heartily thankful to my supervisor, Dr. Aying Liu, for his continuous support and guidance of my Ph.D. study and research in last five years, for his patience, motivation, enthusiasm, inspiration and immense knowledge. Throughout my thesis-writing period, he always provided encouragement, sound advice, good teaching, good company, and lots of good ideas. I could not have imagined having a better advisor and mentor for my Ph.D. study than him. I am also very grateful to Dr. Michael Brookes, my second supervisor, for his kind support.

On the computational techniques, I am also extremely grateful to Dr. Huw Edwards (Loughborough University) and Dr. Timo Baas (IAB, Germany) for CGE modelling advice as well as Prof. William F. Blankenau (Kansas State University, U.S.) for the elasticities of his paper support.

Special thanks to all friends in the Ph.D. student office, Alice, Fawaz, Kailei, Michael, Myint, Naagush and Zhongwei, all my office mates for sharing the experience of research and all the fun we have had in the last five years.

Last but not least, a very special thank you to my family, my parents, Jianhe Wu and Lizhu, Lin, for giving birth to me at the first place and providing emotional, moral and financial support throughout my Ph.D. years, and my wife, Xuan Zheng, for her constant support and encouragement.

Abstract

The aim of this thesis is to make a comprehensive assessment of economic impacts of different skilled level of international immigration labour on the UK by using a multi-region, multi-sector CGE-ILA model as a tool, with four main extensions from the IFPRI standard CGE framework, namely, the four-level nested CES production functions, highly disaggregated household data, two foreign regions and the assumption of imperfect labour market. The model is calibrated to a purpose-built 41x41 SAM dataset for the UK 2004.

By employing four sets of criterions, the analysis combines four skill-type of immigration labour to look at their impacts on the UK economy from six aspects: economic growth, international trade, wage and unemployment, incomes of institutions, employment in sectors, production prices and scale of production. The main findings are:

- 1) The inflow of higher-skilled labour can make significant contribution to UK economy and alleviate wage inequality; although lower-skilled immigration labour also has the positive effects on UK economy, they can worsen the wage inequality.
- 2) Only increase of small proportion (<8%) of highly-skilled immigration labour will reduce total unemployment.
- 3) Increase of immigration labour has positive effects on the incomes of all institutions, of which enterprises and government gain the larger benefit than households do. The higher the skill of immigration labour has, the larger the contribution they will make.
- 4) The unskilled immigration labour has the larger positive effects on UK economy than the semi-skilled has, and has the positive impacts on reducing the activity prices of the some sectors in the Primary and Secondary Industry, and then encourages more exports than imports.
- 5) The semi-skilled immigration labour is the least needed in the UK labour market, if the reduction of unemployment is the prior consideration.

Thus, the policy implication of the current study is that the highly-skilled immigration labour is urgently and largely needed by the UK economy; the recommended scale of immigration labour is a mix with a large proportion of higher-skilled labour force and a small proportion of the lower-skilled.

Table of content

Acknowledgements	I
Abstract.....	II
Table of content	III
List of Figures.....	VIII
List of Tables	IX
List of Acronyms	XIV
Chapter One: Introduction.....	1
1.1 Motivation to the Research Problem.....	2
1.2 The Objectives of the Research.....	5
1.3 Methodology	6
1.4 The Structure of the Thesis	8
Chapter Two: Background of UK Immigration.....	11
2.1 The Scale of Recent Immigration.....	11
2.2 The Features of Recent Immigration.....	14
2.3 The Profile of Immigrant Workers	19
2.4 Development of Immigration Policy	19
2.5 Summary	22
Chapter Three: Literature Reviews of Labour Immigration.....	24
3.1 Introduction	24
3.2 Development of Labour Economics.....	25

3.3	Economic Impacts of International Migration	26
3.3.1	Impacts on Economic Growth	27
3.3.2	Impacts on Labour Market	31
3.3.3	Impacts on Domestic Household.....	34
3.3.4	Impacts on International Trade.....	38
3.3.5	Impacts on Tax Revenue and Public Expenditure.....	43
3.4	Other Impacts of International Migration on Sending and Receiving Countries..	46
3.4.1	Positive Effects of International Immigration	49
3.4.2	Negative Effects of International Immigration.....	55
3.5	Analytical Methods for Assessing Economic Impacts of Labour Immigration	58
3.5.1	Econometric Approaches.....	58
3.5.2	System-Based Simulation Approaches.....	63
3.6	Summary	69
Chapter Four: CGE Model: Basic Theories and Mechanism.....		72
4.1	General Definition of CGE Model	72
4.2	Mechanism of CGE Model: How it Works	74
4.2.1	Procedure of CGE Modelling.....	74
4.2.2	Structure of CGE Model.....	76
4.3	SAM Database in CGE Model	80
4.4	Evaluation of CGE Models	85
4.5	The Application of CGE in Policy Research.....	88
4.6	Summary	92

Chapter Five: Construction of UK CGE-ILA Model	93
5.1 Introduction	93
5.2 Behavioural Relationships among Agents of UK Economy	95
5.3 Transaction Relationships in the CGE-ILA Model	98
5.3.1 Price Relationships of Marketed Commodities in CGE-ILA.....	102
5.3.2 Quantity Relationships	104
5.3.3 Production Relationships.....	105
5.4 Mathematical Statements of the Model.....	107
5.4.1 Price Block	108
5.4.2 Production and Trade Block	112
5.4.3 Institution block.....	120
5.4.4 System constraint block.....	123
5.4.5 Labour Market Imperfection	127
5.5 Closure Rules in CGE-ILA Model	131
5.6 Elasticities and Calibration.....	133
5.7 Summary	139
 Chapter Six: Social Accounting Matrix for UK 2004	 140
6.1 Introduction	140
6.2 Construction of Aggregated UK SAM 2004	141
6.3 Disaggregation of UK SAM 2004.....	143
6.3.1 Sectors	143
6.3.2 Labour Specification	144

6.3.3	Households Division	149
6.4	Characteristics of UK Economy for 2004	153
6.4.1	Economic Structure	154
6.4.2	Factors in Sectors	157
6.5	Summary	158
Chapter Seven: Policy Simulation Results		160
7.1	Introduction	160
7.2	Economic Impacts on Macro-Economic Performance.....	162
7.2.1	Real GDP, GDP per Capita and CPI.....	163
7.2.2	Private Consumption, Fixed Investment, Absorption and Tax Revenue..	167
7.2.3	International Trade.....	169
7.3	Impacts on Labour Market	171
7.3.1	Labour Wages and Unemployment Rate	172
7.3.2	Employment and Factor Incomes	178
7.4	Impacts on Domestic Institutions	181
7.4.1	Incomes and Expenditure of Domestic Institution	181
7.4.2	Welfare of Domestic Households	185
7.5	Impacts on Production Sectors	187
7.5.1	Changes of Labour Demand in Sectors	187
7.5.2	Changes of Production Prices in Sectors	193
7.5.3	Changes of Production Quantity in Sectors.....	199
7.6	Sensitivity Analysis	204
7.7	Summary	212

Chapter Eight: Conclusions	215
8.1 Main Findings of This Study.....	215
8.1.1 On Macro-Economic Performance.....	216
8.1.2 On Labour Market	217
8.1.3 On Incomes of Institution.....	219
8.1.4 On Production Sectors.....	220
8.2 Contributions to the Understanding of the Issues	222
8.3 Methodological Contributions.....	225
8.4 Policy Implication	226
8.5 Limitations and Future Research.....	230
References:	233
Appendix:	249
Appendix 1: Sets, Parameters and Variables	249
Appendix 2: Model Files	254
Appendix 3: The Micro SAM for UK 2004	275
Appendix 4: The Rest Results of Scenarios	278

List of Figures

Figure 2.1	Long-term international migration (LTIM) to/from the UK, 1991-2009.....	12
Figure 2.2	Share of immigrants in employment by country of birth.....	13
Figure 2.3	Scale and composition of foreign net immigration to the UK by nationality, 1991-2008 (thousand and %).....	15
Figure 2.4	Immigration by broad age group, 1991-2008	16
Figure 2.5	Intended length of stay of immigrants to the UK, 1991-2008..	17
Figure 2.6	Reasons for immigrating to the UK, 1991-2008.....	17
Figure 3.1	The Extension of Lewis' Theoretical Model 错误！未定义书签。	
Figure 3.2	The Immigration Surplus in a Model with Homogeneous Labour and Fixed Capital.....	28
Figure 4.1	Steps in computable general equilibrium analysis.....	76
Figure 4.2	Major payment flows in the CGE models	78
Figure 4.3	The family tree of economic models	85
Figure 5.1	Price Relationships for the CGE-ILA Model.....	103
Figure 5.2	Quantity Flows of Marketed Commodities	105
Figure 5.3	Structure of Four Level Production Activity.....	106
Figure 5.4	The Wage Curve	129
Figure 7.1	Impacts of increase in labour immigration on unemployment rate	176
Figure 7.2	Sensitivity Analyses of Elasticities (GDP) for Different Scenarios.....	209
Figure 7.3	Sensitivity Analyses of Elasticities (GDPPC) for Different Scenarios.....	210
Figure 7.4	Sensitivity Analyses of Elasticities (UER) for Different Scenarios.....	211

List of Tables

Table 2.1	Overseas-born population in the UK (%)	11
Table 2.2	Geographical distributions of immigrants to the UK (%), 1991-2008.....	18
Table 3.1	Important dimensions of the Economic Impact of Immigration.....	47
Table 4.1	The basic SAM structure used in the CGE model	84
Table 4.2	Recent Policy Researches on the UK by CGE Model	90
Table 5.1	The Basic Behavioural Relationships for the CGE-ILA model....	97
Table 5.2	Transaction Relationships for the CGE-ILA model.....	101
Table 5.3	Elasticities for different countries' CGE models	137
Table 5.4	Selected Elasticities of different industries in CGE-ILA model ...	138
Table 6.1	Aggregated SAM for UK 2004	142
Table 6.2	Sectors Aggregation in the CGE model.....	143
Table 6.3	International Standard Classification of Occupations (ISCO-88)	145
Table 6.4	Classification of labour types in the CGE-ILA model.....	146
Table 6.5	Economic active population by sectors and labour types, UK 2004 (thousand)	148
Table 6.6	Gross labour income by sectors and labour types, UK 2004 (million £)	148
Table 6.7	The Division of Household (HH) in the UK: 2004	149
Table 6.8	The labour composition of households in the UK: 2004	150
Table 6.9	Gross factor income by household types, UK 2004	152
Table 6.10	Disposable income by type of household, UK 2004.....	152
Table 6.11	Household expenditures by type of household, UK 2004	153

Table 6.12	Aggregate National Accounts Summary (billion pounds)	154
Table 6.13	UK Economic Structure in the Baseline Year 2004 (%)	156
Table 6.14	Factor Shares within Industries (%)	157
Table 6.15	Average Labour Wages by Sector (£1,000).....	158
Table 7.1	Codes and Definitions of Immigration Scenarios.....	161
Table 7.2A	Impacts on UK economic growth under Group A scenarios (+1%).....	163
Table 7.3	Impacts of increasing labour immigration on the growth of real GDP (% change)	164
Table 7.2B	Impacts on UK economic growth under Group B scenarios (+10%)	164
Table 7.2C	Impacts on UK economic growth under Group C scenarios (- 1%)	165
Table 7.4A	Impacts on absorption, private consumption, fixed investment and tax revenue (+1%).....	168
Table 7.4B	Impacts on absorption, private consumption, fixed investment and tax revenue (+10%).....	169
Table 7.4C	Impacts on absorption, private consumption, fixed investment and tax revenue (-1%).....	278
Table 7.5A	Impacts on international trade under Group A scenarios (+1%).	170
Table 7.5B	Impacts on international trade under Group B scenarios (+10%)	278
Table 7.5C	Impacts on international trade under Group C scenarios (-1%).	278
Table 7.6A	Impacts on wages under Group A scenarios (+1%)	172
Table 7.6B	Impacts on wages under Group B scenarios (+10%)	173
Table 7.6C	Impacts on wages under Group B scenarios (-1%).....	174
Table 7.7A	Impacts on unemployment rate under Group A scenarios (+1%)	

	175
Table 7.7B	Impacts on unemployment rate under Group B scenarios (+10%)	175
Table 7.7C	Impacts on unemployment rate under Group B scenarios (-1%)	279
Table 7.8	Impacts of different skill types of immigration labour on total unemployment rate ($\Delta\%$)	176
Table 7.9A	Impacts on employment under Group A scenarios (+1%)	178
Table 7.9B	Impacts on employment under Group B scenarios (+10%)	279
Table 7.9C	Impacts on Employment under Group C scenarios (-1%)	279
Table 7.10A	Impacts on factor incomes under Group A scenarios (+1%)	179
Table 7.10B	Impacts on factor incomes under Group B scenarios (+10%)	280
Table 7.10C	Impacts on factor incomes under Group C scenarios (-1%)	280
Table 7.11	Summary of percentage changes in wage, employment and factor income	180
Table 7.12A	Impacts on domestic institutions' income under Group A Scenarios.....	182
Table 7.12B	Impacts on domestic institutions' income under Group B Scenarios.....	280
Table 7.12C	Impacts on domestic institutions' income under Group C Scenarios.....	183
Table 7.13A	Impacts on domestic institutions' expenditure under Group A Scenarios.....	183
Table 7.13B	Impacts on domestic institutions' expenditure under Group B Scenarios.....	184
Table 7.13C	Impacts on domestic institutions' expenditure under Group C Scenarios.....	184
Table 7.14A	Impacts on domestic households' welfare (Equivalent Variation)	

	under Group A Scenarios (Billion £).....	185
Table 7.14B	Impacts on domestic households' welfare (Equivalent Variation) under Group B Scenarios (Billion £)	186
Table 7.14C	Impacts on domestic households' welfare (Equivalent Variation) under Group C Scenarios (Billion £)	186
Table 7.15	Baseline value of labour demand (thousand) by sectors.....	187
Table 7.16	Percentage change of labour demand by scenarios of highly- skilled labour immigration	190
Table 7.17	Percentage change of labour demand by scenarios of skilled labour immigration	190
Table 7.18	Percentage change of labour demand by scenarios of semi- skilled labour immigration	191
Table 7.19	Percentage change of labour demand by scenarios of unskilled labour immigration.....	191
Table 7.20	Percentage change of labour demand by scenarios of all types of labour immigration	192
Table 7.21	The percentage changes in output prices of activities (PA)	197
Table 7.22	The percentage changes in value added prices (PVA).....	197
Table 7.23	The percentage changes in prices of aggregate intermediate input (PINTA)	198
Table 7.24	The percentage changes in prices of composite goods (PQ).....	198
Table 7.25	The percentage changes in quantity of activities (QA)	202
Table 7.26	The percentage changes in quantity of aggregate value-added (QVA)	202
Table 7.27	The percentage changes in quantity of aggregate intermediate input (QINTA)	203
Table 7.28	Sensitivity test of elasticities on GDP under different scenarios	

	208
Table 7.29	Sensitivity test of elasticities on GDP per capita (GDPPC) under different scenarios	208
Table 7.30	Sensitivity test of elasticities on Unemployment Rate (UER) under different scenarios	208

List of Acronyms

AGE	Applied General Equilibrium;
ASEAN	Association of Southeast Asian Nations;
CES	Constant Elasticity Substitution;
CET	Constant Elasticity Transformation;
CGE	Computable General Equilibrium;
EEC	European Economic Community;
EU	European Union;
GAMS	General Algebraic Modelling System;
GTAP	Global Trade Analysis Project;
HOS	Heckscher-Ohlin-Samuelson model;
IFPRI	International Food Policy Research Institute;
IMF	International Monetary Fund;
NEG	New Economic Geography model;
OECD	Organisation for Economic Co-operation and Development;
ROE	Rest of EU;
ROW	Rest of World without EU;
SAM	Social Accounting Matrix;
SSA	Systematic Sensitivity Analysis.

Chapter One: Introduction

“At a time of great population movements we must have clear policies for immigration and asylum. We are committed to fostering social inclusion and respect for ethnic, cultural and religious diversity, because they make our societies strong, our economies more flexible and promote exchange of ideas and knowledge.”

*Communique of Heads of Government,
Berlin Conference on Progressive Governance, June 2000*

The last three decades have witnessed a profound changing trend of international immigration from developing countries to developed countries. It is reported by International Organisation for Migration (IOM) that there were about 56 million immigrants in the Europe, 50 million in the Asia and 41 million in the North America, of which more than 40 percent are from the developing countries (IOM, 2003).

The issues of international migration have attracted more and more attentions by governments and the international communities, among other hot topics and important concerns such as preventing infectious diseases, natural disasters, energy crises, terrorism and reducing poverty. For example, in the occasion of the United Nations’ (UN) 60th anniversary, world leaders unanimously acknowledged that there is a close link between international migration and economic development; international migration provides both opportunities and challenges for the countries of origin, destination and transit (UN, 2005).

International migration, as a historical and old phenomenon, has been pushed recently by the globalisation movement started around year 2000. The globalisation process

may create some new opportunities for world economic development and employment by rationalising the allocation of production factors, including labour, with the international scope, but it may also bring some challenges and problems such as the impacts of international labour mobility on unemployment and social welfare of the host countries.

In theory, it is widely believed that free trade, including free labour movement, is beneficial to every part as it can remove unnecessary man-made obstacles of factor re-allocation and maximise everyone's comparative advantage hence to maximise total well-being of the whole mankind. But in practice, many countries, particularly developed countries have been trying to be blind or avoid the discussion of this issue on the negotiation tables of WTO (World Trade Organisation) around, despite the fact that labour migration is one of critical issues of the international economy over a long time period. For example, the US always refuses the free flow of labour within the North American Free Trade Agreement (Chen, 2002). Even within the European Union (EU), which declared the free movement among member countries, many old EU member countries (i.e., Germany, Spain) still set the restriction on the labour immigration, while the UK and Ireland open their labour market without restriction (Baas and Brucher, 2007).

1.1 Motivation to the Research Problem

Immigration to the United Kingdom of Great Britain and Northern Ireland (the UK) since its present political creation in 1922 has been substantial, in particular from the Republic of Ireland and the former colonies and other territories of the British Empire. It has been an important phenomenon that the UK has changed from being a country of negative net immigration in the 1960s and 1980s to one of positive net immigration during 1980s with sharp increases occurring from the mid-1990s (Hatton, 2005).

During this period, the out-migration to the Old Commonwealth, mainly Australia and Canada, was declining, whilst the net immigration from the New Commonwealth (Bangladesh, India, Sri Lanka and Pakistan) was increasing until very recently. At the same time, there was a strong upward trend in net migration from the EU. The number of immigrants increased more than double from 1992 to 2004, which at about 582,000 (Migration Watch UK, 2009). Since the EU enlargement in 2004, a new wave of mass immigration from new EU member countries to the UK has been witnessed.

Immigration has become highly significant to the UK economy, immigrants comprises 12% of the total workforce and a much higher proportion in London (ONS, 2009). However, it has been a persistent debate whether net immigration generates significant economic benefits for the existing UK population or not; the public opinions are rather contradictory about its impacts on the national economy, social welfare and labour market impacts. Some (Blanchflower and Shadforth, 2007) argued that migrants can assist economic growth and reduce inflationary pressures, either by dampening wage demands or by filling existing skill shortages, other (the House of Lord, 2008) are particularly paying attention on possible negative effect of immigration on wages and employment outcomes of already resident workers.

There are a number of research issues which have been consistently core but debateable questions in the field of impacts of international migration on the UK economy:

- 1) Which criterion(s) should be used for assessing the economic impacts of immigration on the UK, and particularly, whether overall GDP is a relevant or a misleading criterion? Many believe that the total size of an economy is not an index of prosperity, and the focus of analysis should rather be on the effects of immigration on income per head of the resident population.
- 2) What levels and types of immigration labour force are desirable as the economic

impacts of immigration depend critically on the skills of immigrants; and whether additional immigration carries benefits or disadvantages? Because the impacts of immigration depend critically on the skills of immigrants; different types of immigrant can have very different impacts on the economy.

- 3) Whether net immigration is indispensable to fill labour and skill shortages in the UK labour market, in which immigration labour reduces the existing vacancies and also creates new vacancies in the mean time? As some believe that making use of the skilled and hard work of immigrants is not an argument for immigration on a scale which exceeds emigration and increases the population of the country.
- 4) Does immigration generate fiscal benefits to the host country, and if yes, how big is the impact on this aspect? The core part of the argument is about who counts as an immigrant and what items to include under costs and benefits on which the fiscal impacts are estimated.
- 5) What are the potentially important economic consequences of immigration for the welfare of the residents in the host country by considering the impact of rising population density on the cost and speed of implementation of public infrastructure projects?

All those questions remain poorly understood; there are significant unknowns and uncertainties in the existing literature on immigration and immigrants in the UK.

There are a considerable number of empirical papers addressing the impacts of immigration on the labour market of host countries (see Borjas 1994, 1999, or Friedberg and Hunt, 1995). Most of these studies relate to the US and typically use micro-data from the US census (see for example, Altonji and Card 1991; Borjas, Freeman and Katz 1996; Card, 1990; Card, 2001; Kuhn and Wooton 1991; Lalonde

and Topel 1991), but much less work exists for countries outside the US.

Baas and Brucker (2008) analyse macroeconomic impact of eastern enlargement on Germany and UK by using a Computable General Equilibrium (CGE) model. The authors consider the aggregate labour immigration mainly from the new EU member countries, but they ignored the immigration from outside of EU and the human capital of the migrants.

There is lack of sufficient analyses for the accurate measurement of the questions mentioned above. The gaps in the field created significant difficulties for public debate and for policy making of immigration; further in-depth research is urgently needed. The purpose of the current research is to fill in this gap.

1.2 The Objectives of the Research

As one of the most developed countries, the UK has been conducting a free-trade policy and has a great attraction in international labour inflow. However, the mobility of labour is always not as that of capital or other factors, and also a problematic issue in terms of both international trade and domestic social welfare and unemployment affairs. The purpose of this thesis attempts to quantify the impacts of labour immigration into the UK using a computable general equilibrium model of the UK economy. Therefore, the objectives of this study are fourfold:

1. To provide a description of the scale, the speed, the achievement and the main problems of the current immigration situation in the UK.
2. To assess the economic impacts of international labour immigration on the UK economy from four broad aspects, namely economic growth, labour market, social welfare and production sectors by using four sets of criterions

and indicators.

3. To enrich our understanding of the theoretical aspects of international immigration, by providing a piece of further evidence from the UK case, not only to the British policy makers, but also to the international community in general.
4. To test whether the CGE model is an effective and efficient approach for analysing the impacts of immigration labour, and what kinds of deviation, modification and preparation need to be done for applying the model.

1.3 Methodology

In order to achieve the objectives mentioned above, a specific CGE model has been constructed for the UK to analyse the interactions between different skill types of labour immigration and the remainders of the UK economy, such as economic growth, domestic labour market, and production sectors.

A CGE model is very useful for this type of analysis as it is derived from micro-economic optimisation behaviour under constraints of all agents in the economy. Unlike other partial equilibrium or macro-econometric approaches, CGE model is calibrated to a comprehensive set of consistent and balanced macroeconomic accounts, the Social Accounting Matrix (SAM) (Bohringer *et al*, 2003). Since such a model is built to be consistent with micro-optimal outcomes, it can provide comprehensive and internally consistent predictions regarding to the effects of immigration labour on the UK economy.

A CGE model can also be made sufficiently disaggregated, fit to the purpose of the

study, and subsequently put to use in simulations of how changes in certain economic conditions are mediated through price and quantity adjustments in markets.

Moreover, the CGE technique allows for counterfactual analysis, i.e. answering ‘what if’ questions, and is not just restricted to ‘learning from the past’ like econometric studies are. A CGE model thus possesses strong theoretical foundations and imitates the functioning of the economy by capturing the interactions between the various agents of the economy.

Based on the standard CGE model, there are five main extensions will be made in this research. Firstly, different from most of existing economic studies which focus on the labour supply-side considerations, this study will take different angle by looking at the issues from the demand-side in production sectors.

Secondly, studies at highly aggregated level might provide some general conclusions or insights, but there are not able to reveal detailed or/and more accurate information, sometimes they can also twist the true pictures. This study will introduce more disaggregated level of economic agents into the CGE model, such as four different skill types of labour groups, five different income levels of household classes, and nine types of aggregated production sectors.

Thirdly, a set of corresponding four-level nested Constant Elasticity of Substitution (CES) production functions will be introduced into the model for the substitution relationships among capital and different skill-types of labour.

Fourthly, EU is a unique economic body with variety of economic policies toward its member countries. As the UK is one of the EU member countries, from the CGE modelling viewpoint, instead of one foreign entry (ROW), two foreign entries will be considered in the model (i.e., ROE and ROW)

Fifthly, in the classical modelling, the full employment assumption has been always questionable and debatable. In order to correct or modify the unrealistic assumption, the Wage Curve function will be introduced to measure the relationships between wage rate and unemployment rate, to reflect the interactive and changing feature of those two, with the CGE framework.

1.4 The Structure of the Thesis

The remainder of this thesis is organised as follows. Chapter 2 provides general information on the background of UK immigration. Due to the increasing immigrants, the policies toward immigration to the UK have been changed dramatically since 1970s. Chapter 2 firstly provides the detail of recent immigration scale, and then analyses the features of recent immigration and finds out the profile of immigration workers in the UK. This chapter also describes the development of immigration policies in the UK.

In order to understand the behaviour of immigration, Chapter 3 firstly reviews the theories of international migration. Then, based on the former researches, the chapter analyses the economic impacts of international immigration on economic growth, labour market, household welfare, international trade and fiscal consequences. The comprehensive positive and negative effects of international migration on both sending and receiving countries are also presented. Finally, the chapter surveys the existing analytical methods which are used to assess the economic impacts by of labour immigration, such as simulation-based analyses and econometric analyses, and chooses an appropriate method for this study, which is CGE method.

Chapter 4 provides a brief history of Computable General Equilibrium (CGE) model,

discusses the conceptual framework and its mechanism. The functions of Social Accounting Matrix (SAM) in CGE model are presented. Moreover, the chapter also evaluates the application of CGE model in policy analysis and takes some examples on the UK policy research.

Chapter 5 builds up an extended IFPRI CGE model that focuses in particular on the UK with different skilled labour immigration effects. The model descriptions place particular emphasis on the behavioural and transaction relationships among UK agents used in the CGE-ILA framework. Then a complete system of equations is built up for the model in mathematical form. The closure rules are set up for the model. In addition, this chapter also chooses the corresponding elasticities from outside studies.

Chapter 6 details the construction of database, the UK 2004 Social Accounting Matrix (SAM), to which the CGE-ILA model of Chapter 5 is calibrated, in tabular form. It contains economic data disaggregated by sectors, which are predominantly taken from the UK Input-Output Supply and Use Tables for 2004 and are distributed over factors and households using data from UK National Account Blue Book 2006 edition. The labour are divided into four different skill types and the households are divided evenly into five different income level households by the data from International Labour Organisation (ILO) for UK 2004 and the Annual Survey of Hours and Earnings for the year 2004 (ASHE). Then the GAMS (General Algebraic Modeling System) software is used to analyse the characteristics of UK economy for baseline year 2004.

The main results of the model simulations are presented in Chapter 7. These results are drawn from four parts of effects by increasing or decreasing labour supply from five different possible skill types of labour immigration in small and large scale. The first part measures the impacts on macro-economic performance are measured in terms of the changes in the level of real Gross Domestic Product (GDP), GDP per capita, Consumer Price Index (CPI), private consumption, fixed investment, absorption,

indirect tax revenue, and trade with two foreign regions (ROW and ROE). The second part discusses the impacts on UK labour market, including labour wages, unemployment rates, labour incomes and employment. The third part analyses the impacts on existing domestic institutions, such as households' incomes, expenditures and welfares. The sectoral effects are described in the fourth part in terms of changes in the levels of labour demand, production prices and outputs. Finally, the sensitivity analysis is reported as a test of model robustness by conducting the Systematic Sensitivity Analysis.

Finally, Chapter 8 summarises the final conclusions, compares the model results with other previous studies, discusses the feasible policy recommendations for the immigration to the UK, points out the model's limitations and suggests extensions for future research.

Chapter Two:

Background of UK Immigration

UK has a long history of migration, both immigration and emigration. The UK population is the result of successive inflows of migrants and the racial and cultural intermixture of those migrants with those who were already there (Glover *et al*, 2001). This chapter is going to find out the key characteristics of recent international immigration to the UK on the scale, features and demographic impacts, and then review the development of immigration policy in the UK.

2.1 The Scale of Recent Immigration

The size of the immigrant population has grown significantly over last six decades. The rise in net immigration has increased the share of foreign-born persons in the UK population. By 2009, more than 1 in 9 UK residents (6.9 million people) had been born overseas, which is nearly treble the proportion in 1951 (4.22%) and double in 1981 (6.23%) (show in Table 2.1 below). During the period 2001–06, total net immigration accounted for almost two thirds of the UK's population growth (House of Lords, 2008, p11).

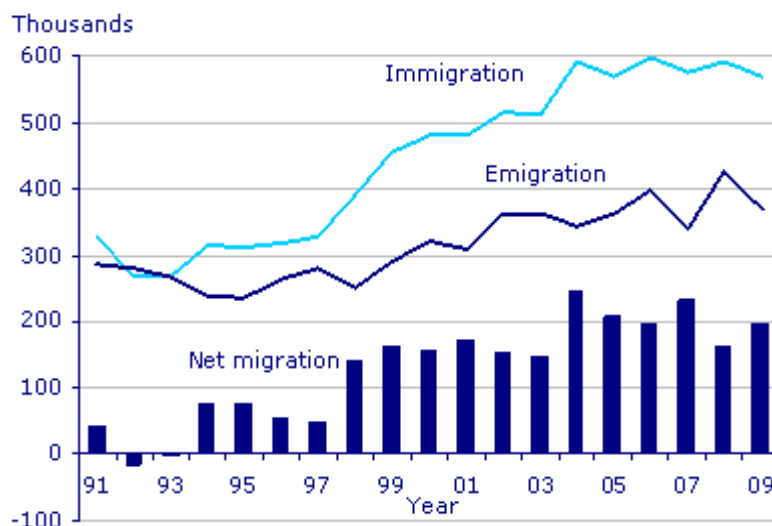
Table 2.1 Overseas-born population in the UK (%)

Year	Percentage
1951	4.22
1961	4.88
1971	5.75
1981	6.23
1991	6.69
2001	8.33
2009	11.36

Data source: Office for National Statistics

Currently, the main source of information on migration flows to and from the UK is the Long-Term International Migration (LTIM) estimates, mainly based on responses to the International Passenger Survey (IPS) data. The Figure 2.1 below describes the detailed amount of migration to and from the UK during the period 1991 to 2009 using the LTIM estimates. Hatton and Price (2005) estimated that net migration to the UK was negative until the early 1990s. They summarised that total emigration from the UK between 1946 and 1993 was 9.5 million, whilst total immigration was 7.6 million. Figure 2.1 shows net migration to the UK has increased significantly from 1994. Net immigration has risen from around zero in the early 1990s to more than 150,000 a year in 2008.

Figure 2.1 Long-term international migration (LTIM) to/from the UK, 1991-2009

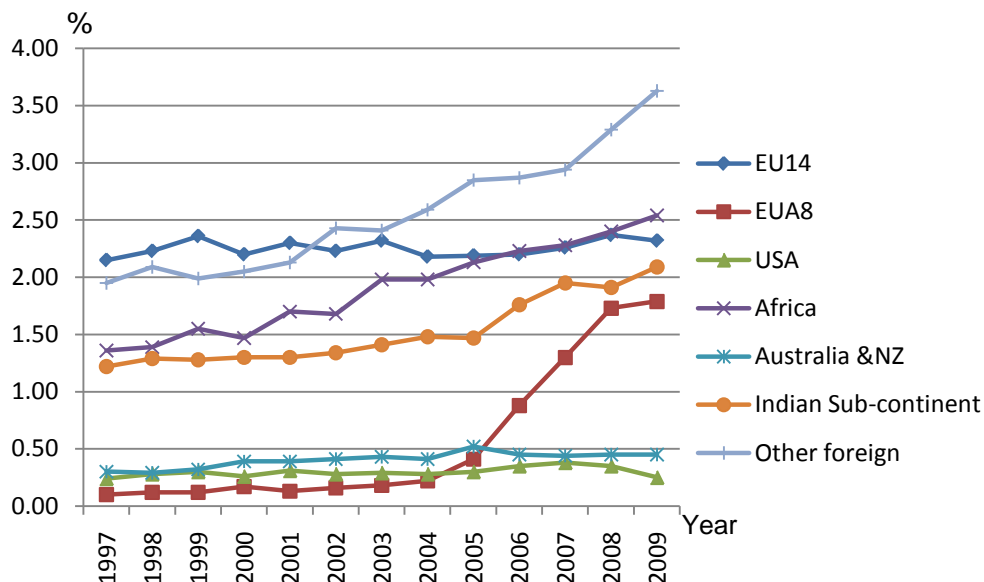


Source: Office for National Statistics

Due to the EU enlargement in 2004, the trend of immigration in Figure 2.1 has changed dramatically since then. In absolute terms immigration increased from 268,000 in 1992 to 582,000 in 2004. Emigration also increased over the period 1992 to 2004 from 281,000 to an estimated 360,000. Net migration reached 223,000 in 2004, 72,000 more than the previous year and the highest level since 1991. In 2004 net out-migration of British citizens reached a record level of 120,000 while net in-migration

of non-British nationals also reached a record level of 343,000.

Figure 2.2 Share of immigrants in employment by country of birth



Source: Office for National Statistics

Figure 2.2 above, based on data from the Labour Force Survey, demonstrate the changing share of immigrants in employment by country of birth over the period 1997 to 2009. During the late 1990s, EU14 (old EU member countries) maintained the largest proportion of immigrants to the UK. Since 2000, the fastest increasing numbers of immigrants were born in Africa (1.47% in 2000 to 2.53 in 2009) and the India sub-continent (1.3% in 2000 to 2.09% in 2009). The immigrants from other foreign, includes rest of Asia, rest of Europe and rest of America, also had a steadily increase from 1.95% to 3.63% during this immigration wave. Most of immigrants from these areas were high-tech immigrants by applying work-permit visa to enter the UK labour market.

Since the fifth enlargement of European Union (EU) in May 2004, the rapid increases in the size of the free movement of labour from Eastern Europe reach the UK. The expansion of EU has been a catalyst for recent increases in flows of international

migration to the UK. The immigrants from A8 countries, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia, had a dramatically jump increase from 0.22% of total employment in 2004 to 1.79% in 2009. Bank of England also concluded that A8 immigrants account for one in three of new immigrants since 2004.

In addition, illegal migrants entering the UK were not counted on the legal way, which were also a hard problem for all governments. About 50,000 illegal entrants are detected every year but nobody knows how many succeed in entering undetected (Migration Watch UK, 2007). Home Office published an estimate of 430,000 illegal immigrants in the UK in 2001 (the average of a wide range) based on a number of indirect estimates. In March 2009, a study at the London School of Economics estimated that the number lay between 524,000 and 947,000 with a midpoint of 725,000 (Migration Watch UK, 2009).

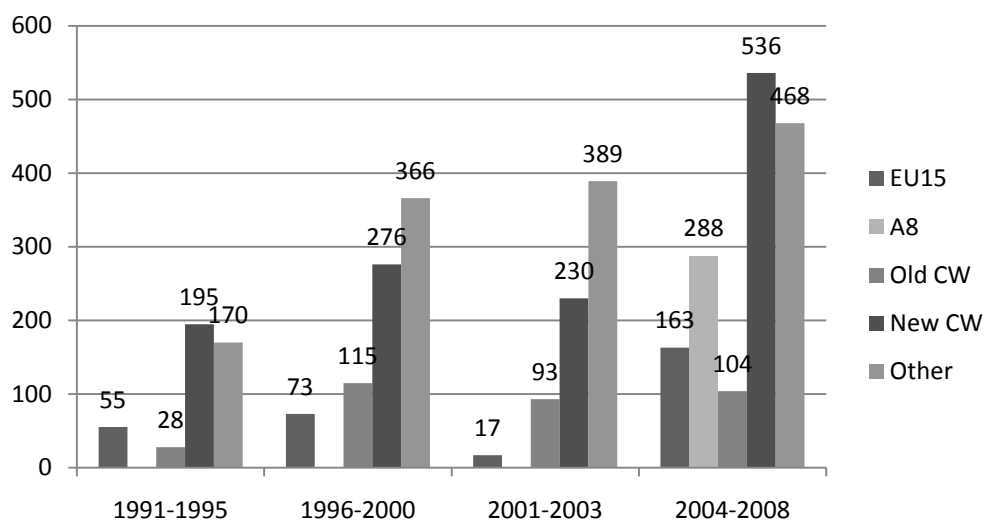
Under the principal variant of the 2004-based population projections of the Government Actuary's Department (GAD), the UK population is expected to grow gradually from about 59.8 million in 2004, passing 60 million in 2005 and 65 million in 2023, and reach 67.0 million by 2031. This is due to a combination of higher assumed levels of net migration, higher short-term birth rate assumptions and slightly higher medium-term life expectancy assumptions (Shaw, 2006).

2.2 The Features of Recent Immigration

The characteristics of recent immigration to the UK are based on International Passenger Survey (IPS) estimates of Long-Term International Migration and cover country of birth, working age, reasons for migrating to the UK, intended length of stay and the location of immigrants within the UK.

As can be seen in Figure 2.3, which shows the changes in pattern of net immigration (inflow minus outflow) since the early 1990s, the number of net immigration increased significantly during recent five years compared with the first five years in 1990s. The percentage of net immigration from EU15 decreased gradually before 2004. However, since the EU enlargement in 2004, it increased noticeably as well as the percentage of net immigration from A8. The number of net immigration from new commonwealth countries also increased, but the percentage of it decreased because the total net immigration increased much faster. As A8 countries were separated from other foreign countries in 2004, the percentage of net immigration from other foreign countries declined significantly.

Figure 2.3 Scale and composition of foreign net immigration to the UK by nationality, 1991-2008 (thousand)



EU15: the fifteen EU member states before EU enlargement in 2004

A8: the eight East European countries that joined the EU in 2004

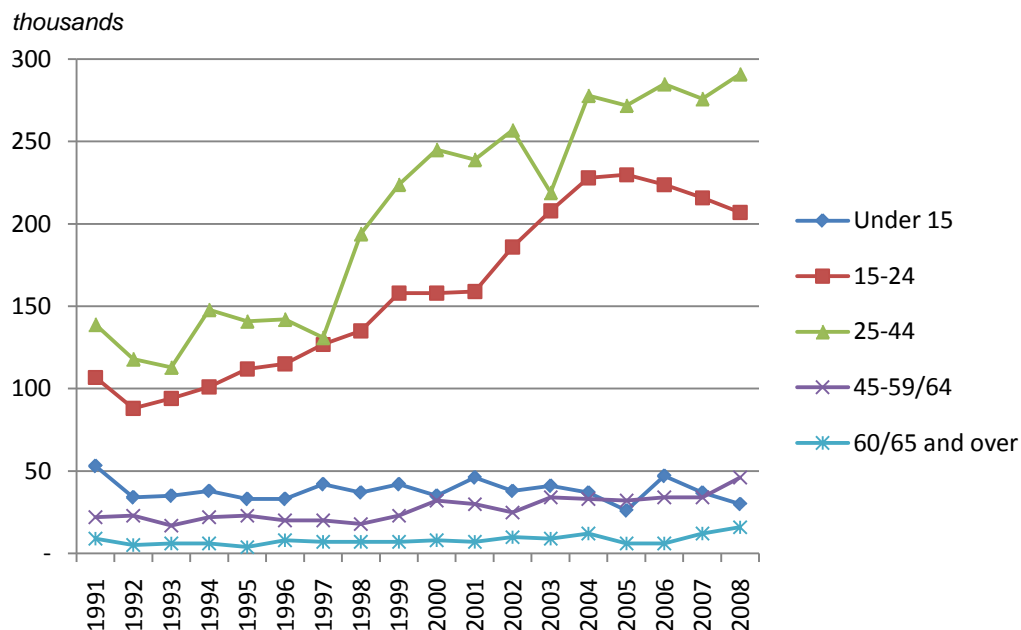
Old Commonwealth (Old CW): Canada, Australia, New Zealand and South Africa

New Commonwealth (New CW): all other Commonwealth countries

Source: ONS, Long-Term International Migration (LTIM) tables, 1991-2008

Figure 2.4 below displays that most immigrants to the UK are younger adults from age 15 to 44. Since 1998, nearly half of all people entering the UK were aged 25-44, and about 35 percent were aged 15-24. These younger immigrants were the best blood to refresh the ageing UK labour market.

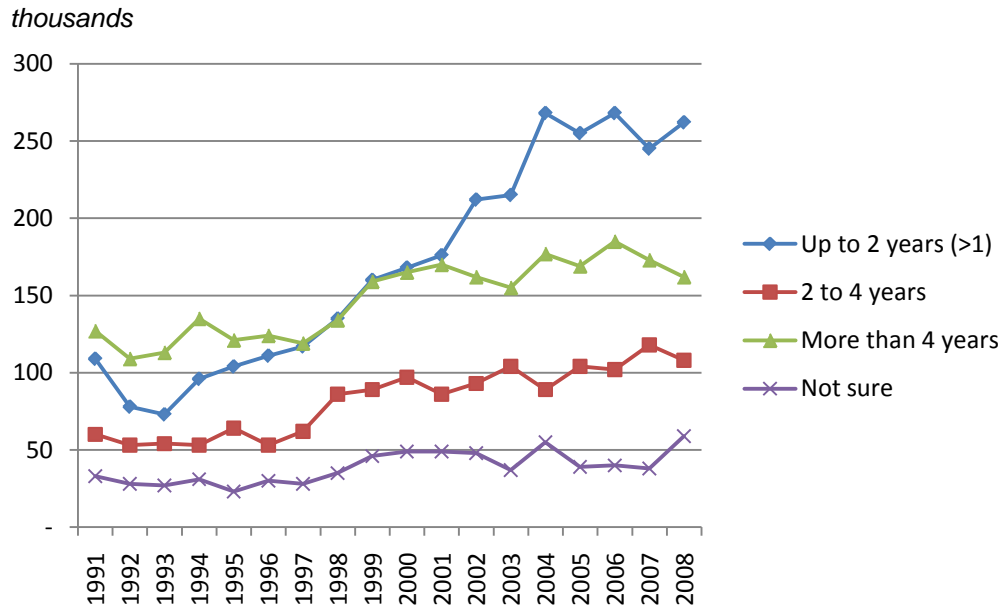
Figure 2.4 Immigration by broad age group, 1991-2008



Source: ONS, Long-Term International Migration (LTIM) tables, 1991-2008

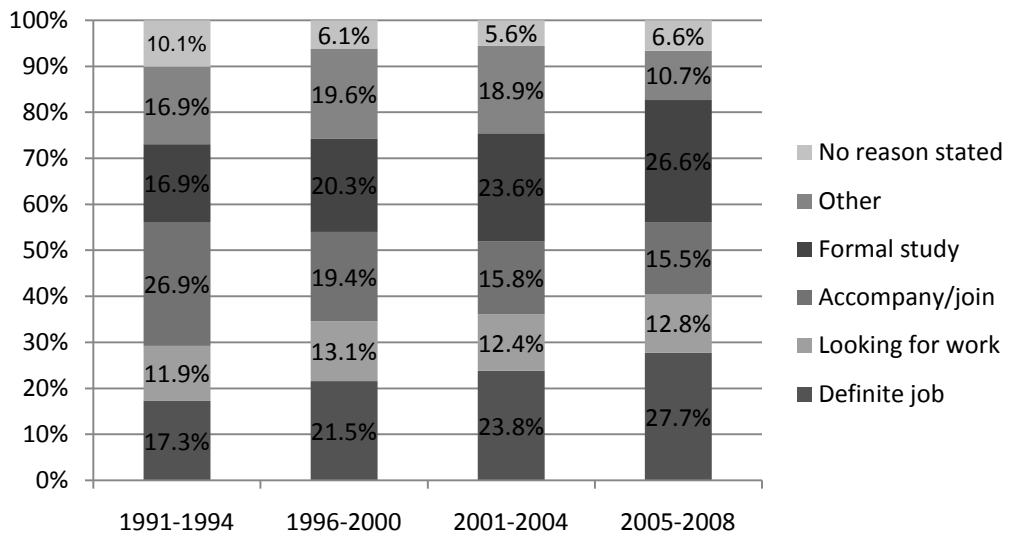
The economic impact of immigration depends partly on immigrants' length of stay in the UK. As Figure 2.5 shows, in recent decade it has become increasingly prevalent for immigrants to the UK to be on a short period basis (1-2 years). Among new immigrants since 2004, about 45% said they intended to stay for 1-2 years (up from 27% in 1993), followed by 18% who said they intended to stay for 3-4 years, and 30% more than 4 years. However, Spencer et al (2007) suggested that there was a significant share of immigrants change their intention from a short-term to a longer-term or permanent stay in the UK. Dustmann and Weiss (2007) also found significant variation in return propensities across immigrants from different origin countries and of different ethnicity. Return migration is significant for immigrants from the EU, the Americas and Australia and New Zealand. In contrast, it is much less pronounced for immigrants from the India sub-continent and from Africa (House of Lords, 2008).

Figure 2.5 Intended length of stay of immigrants to the UK, 1991-2008



Source: ONS, Long-Term International Migration (LTIM) tables, 1991-2008

Figure 2.6 Reasons for immigrating to the UK, 1991-2008



Source: ONS, Long-Term International Migration (LTIM) tables, 1991-2008

Intentions of stay are related to immigrants’ reasons for coming to the UK. There are three main reasons for immigration to the UK and Figure 2.6 demonstrates the percentage of reasons for immigrating to the UK from 1991 to 2008. Firstly, for work related reasons, includes having a definite job and looking for work, are the main

reasons for people to entering the UK. The percentage of looking for work remained similarly at about 12% from 1991 to 2008, but the percentage for immigrants who already had a definite job increased steadily from 17.3% to 27.7%. Secondly, for formal study purposes, it also had a significant increase from 16.9% to 26.6%. Thirdly, the amount for accompanying family reunion did not fluctuate to much at about 80,000, but the proportion of it decline obviously from 26.9% to 15.5% because of the increase of total immigration.

Table 2.2 shows the geographical pattern of immigrants' destinations in the UK during the period of 1991 to 2008. There are approximate 9 out of every 10 immigrants choosing to live in England. Although the immigrants have been highly concentrated in London (39.3% in 1996), this proportion has fallen slightly in recent years (27.6% in 2008). The South East is the second most popular destination for immigrants (14.2% in 2008), followed by East (9.2%) and Yorkshire and the Humber (9%). The recent change of immigrants' locations has been mainly due to the arrival of Eastern European migrants who have been much more widely distributed across the UK than other migrant groups (House of Lords, 2008).

Table 2.2 Geographical distributions of immigrants to the UK (%), 1991-2008

	1991	1996	2001	2004	2008
United Kingdom	100	100	100	100	100
England	89.4	91.5	91.3	91.2	86.8
Wales	3.0	2.5	2.1	2.0	2.7
Scotland	6.4	5.0	5.6	6.3	7.5
Northern Ireland	1.2	0.9	1.0	0.7	3.1
North East	2.1	0.9	2.5	2.2	3.9
North West	5.2	5.7	6.2	8.1	7.6
Yorkshire and the Humber	6.7	4.4	7.5	8.7	9.0
East Midlands	4.3	4.7	4.2	5.9	3.9
West Midlands	4.9	8.2	6.7	5.8	6.3
East	8.5	8.2	8.1	8.0	9.2
London	35.3	39.3	36.8	31.6	27.6
South East	16.1	14.5	13.7	13.1	14.2
South West	6.4	6.0	5.4	7.8	5.3

Source: ONS, Long-Term International Migration (LTIM) tables, 1991-2008

2.3 The Profile of Immigrant Workers

Labour Force Survey data for 2006 suggest that the three most popular sectors for foreign-born workers in the UK are public administration, education and health (32%), distribution, hotels and restaurants (21%) and banking, finance and insurance (20%). Among A8 immigrants, the top sectors are distribution, hotels and restaurants (24%), manufacturing (21%) and construction (14%). In some sectors and regions, the share of immigrants is much higher.

The submissions from the Bank of England showed that, although employed across all occupations, immigrants are concentrated at the high and low skill end of the occupation distribution. The City of London illustrates this range of occupations, where immigrants are widely found among the staff of the restaurants serving financial executives, many of whom are also immigrants. Overall, more foreign-born workers are in highly-skilled jobs than the UK-born (49% vs. 42%), with similar levels for elementary occupations (12% vs. 11%). But A8 immigrants are more concentrated in low-skilled jobs, with 38% in elementary occupations and only 13% in higher-skilled occupations (House of Lords, 2008).

The determinants of immigrants' earnings in the UK include proficiency in English language skills, work experience, education, ethnicity, agency working and length of time spent in the UK (House of Lords, 2008).

2.4 Development of Immigration Policy

With the development of immigration in the UK, the government policies toward immigration are also developing and improving gradually. From the mid-eighteenth century until at least 1947, and longer in many areas, the British Empire covered a large proportion of the globe and at its peak over a third of the world's people lived

under British rule. Both during this time, and following the granting of independence to most colonies after Second World War, the vast majority of immigrants to the UK were from either current or former colonies, most notably those in the Indian subcontinent and the Caribbean (Migration Watch UK, 2009).

The British Government's immigration policy has developed through a number of stages. Until 1962, there was no control on immigration to the UK. The British Nationality Act 1948 encouraged 800 million subjects to live and work in the UK without needing a visa after the Second World War. These people filled a gap in the UK labour market for unskilled jobs and helped the UK recover from the war rapidly. New commonwealth immigration, made up largely of economic migrants, rose from 3,000 per year in 1953 to 46,800 in 1956 and 136,400 in 1961 (Turner, 2003). The heavy immigration caused the pass of Commonwealth Immigration Act in 1962, which started the limitation on immigration to the UK. The new Act required migrants to have a job before they arrived, to possess special skills or who would meet the 'labour needs' of the national economy. However, the tightening of the rules during the 1960s reflects the continuing immigration from the New Commonwealth, running at between 30,000 and 50,000 per annum, numbers far in excess of those in the 1950s (Hatton and Price, 2005)

The immigration Act of 1971, which is the main basis for British immigration policy, abolished the distinction between Commonwealth and non-Commonwealth entrants. Only holders of work permits, or people with parents or grandparents born in the UK could gain entry to the UK. Irish citizens and nationals of European Economic Area countries are essentially free to live and work in Britain. The number of work permits is not subject to an overall quota but permits are issued according to the level of qualification or for specific occupations in demand (Hatton, 2005). Work permits are available on long-term for four years and short-term for groups like business people, journalists, diplomats, sports people and entertainers. In the 1970s, an average of

72,000 immigrants were settling in the UK every year from the Commonwealth; this decreased in the 1980s and early 1990s to around 54,000 per year, only to rise again to around 97,000 by 1999. The total number of Commonwealth immigrants since 1962 is estimated at around 2.5 million (Migrationwatch, 2001).

Since the 1970s, the work permit system has been slightly modified, but had major revisions in 2000 and 2002. The number of work permits issued fell from 75 thousand in 1969 to a low of 15 thousand in 1982, rising again to 80 thousand in 1999 (Hatton, 2005). The sharp rise in the number of work permits issued in the late 1990s is indicative of a significant relaxation of policy adopted by the labour administration from 1997 onwards, including an increased allocation of work permits and relaxation of controls on non-economic immigration (Hatton, 2005). Under the 2002 Act, the government introduced a further expansion of immigration routes including new programme to attract highly-skilled immigrants, based on a points system.

Migrants under the work permit system may obtain indefinite leave to remain or be accepted for settlement and then eventually qualify for UK citizenship. Spouses and children of primary immigrants can also acquire the right to settle and work in Britain, subject to certain criteria. In some circumstances, the right to family reunification is extended to parents and grandparents and to fiancée. In 1998, 20 thousand entered as dependants of work-permit holders and another 50 thousand under the family reunification scheme (Hatton, 2005).

The other main groups of migrants to the UK are students and refugees. Students are admitted if accepted for a course at a recognised educational institution, but without the right to work and only for the duration of the course. Britain's policy towards asylum seekers is based on its obligation under the 1951 Refugee Convention and its 1967 Protocol. About one third of asylum claims are accepted, either as Convention refugees or under the discretionary category of 'exceptional leave to remain'. However,

in the early 1990s the perceived threat was the growing number of asylum seekers, most of whom were regarded as poor unskilled 'economic migrants' (Hatton and Price, 2005). Thus, immigration policy in the 1990s once more represents a tightening of restrictions.

The development of the UK's labour immigration policies since the early 2000s, and of the new Points-Based System, introduced in 2008, in particular, has been explicitly based on a set of policy objectives that puts significant weight on economic goals and that are focused on 'making migration work for Britain' (Home Office, 2006). The policy is focusing on selecting highly-skilled and skilled immigrants without a formal quota or limitation, but no lower-skilled programmes. Thus, there are two questions for debate towards this policy. Firstly, the government's view that immigration generates very large economic benefits for the UK, which underpinned the significant expansion of labour immigration from both outside and within the EEA in recent years, is not supported by the available research evidence for the UK or by assessment of the economic impacts of immigration in other countries (Ruhs, 2008). Secondly, the policy did not concern lower-skilled immigration, which is still scarce in the social-care sector, agriculture and food processing.

2.5 Summary

This chapter reviews the background of UK immigration, including scale, features and profile of recent immigrants, and the development of immigration policy in the UK. By 2009, there are about 6.9 million people in the UK are immigrants, which take more than 1 in 9 UK residents. Most of immigrants are from EU14, Indian sub-continent and Africa. Since the EU enlargement in 2004, the immigrants from A8 countries have been seen a dramatically increase. About 80 percent of immigrants are younger adults from 15 to 44, which refresh the aging population in the UK labour

market. The immigrants are more willing to stay longer time in the UK and about 90 percent of them are in England and about 30 percent concentrate in London. More foreign-born workers are in highly-skilled jobs than the UK-born, but A8 immigrants are more concentrated in low-skilled jobs. The recent situation of international immigration in the UK stimulates people to find out more about the impacts of immigration on both macro and micro economy.

British immigration policy has been developed from 1960s to start the limitation on immigration to the UK. However, although the policy towards immigration is getting more and more restriction, the numbers of immigrants towards the UK are keeping growing. The most recent Points-Based System allows highly-skilled and skilled labour to immigrate but does not show any programme for lower-skilled immigration labour.

Chapter Three:

Literature Reviews of Labour Immigration

3.1 Introduction

Immigration is a contentious issue in the industrialized nations of the world, and many of the key issues in the debate on immigration policy are economic. As a basic structural feature, the emergence of international migration of nearly all industrialized countries testifies to the strength and coherence of the underlying forces. Therefore, it is important to reveal the theoretical foundations of this phenomenon, and the consequent effects on the receiving countries. However, it is easy to get lost in the multiplicity of empirical research results produced until now. Different studies analyse different data sets over different time periods using different techniques. It is undoubted that new approaches will follow in the future as globalisation will keep the migration issue on the agenda (Okkerse, 2008).

The purpose of this chapter is to review the existing literature in the contemporary theories of international immigration and its impacts on social and economic development. Section 3.2 describes the development of labour economics and then presents the theories of international immigration in section 3.3. Section 3.4 provides recent international empirical researches on the main dimensions of economic impacts of international immigration, namely, economic growth, labour market, native household, international trade and fiscal. Section 3.5 discusses the potential positive and negative impacts of international migration on both sending and receiving countries. Section 3.6 discusses and evaluates the different analytical methods for assessing the economic impacts of labour immigration. And section 3.7 summarises.

3.2 Development of Labour Economics

As a main factor of production, labour is a measure of the work done by human beings. With the emergence of capitalism mode of production and development, labour employment relationship extends to all areas of social life. In relation to this, labour issues have become increasingly prominent, such as unemployment, wages, working conditions, industrial accidents, labour negotiations, strikes, etc. Therefore, early labour economists were attracted to develop a series of labour theories. During mid-19th century, the term 'labour policy' began to appear in the economics literature. Since then, many western countries considered labour policy as an important part of social and economic policy in order to maintain economic development and social stability, for example, minimum wage system, labour time, social insurance, vocational and technical education, Factory Act, Labour Union Act, and so on.

In 19th century, some utopian socialist has been thoroughly exposed and criticized the exploitation of capitalist system. They tried various ideas and experiments to establish a rational social system which would improve the labour situation. Karl Marx and Frederick Engels, founders of scientific socialism, made a profound analysis of labour issues under the capitalist system and made scientific prophecy about labour relations in socialist society in their famous works, "Das Kapital", "The Condition of the Working Class in England" and other works.

In the early 20th century, there were some famous books specializing in labour economics and labour issues. The father of scientific management, Frederick W. Taylor (1856 – 1915), published "The Principles of Scientific Management" in 1911, which was a significant contribution to the micro labour management. In 1925, Solomon Blum published the first textbook of "Labour Economics" in New York, including employment, wages, labour movement, labour legislation and other major elements. No longer later, the first global capitalist economic crisis caused serious

labour problems. Therefore, this stimulated a great progress on the development of Labour Economics. John Maynard Keynes, a well-known British economist, put forward theories of ‘insufficient aggregate demand for goods’ and ‘involuntary unemployment’, which had important implications on the development of labour economics. In addition, the study of Western modern management methods, such as behaviour science and ergonomics, also enriches the content of labour economics.

International migration is a main part of labour economics. Economic theory considers international migration a universal socio-economic phenomenon with a long history, a process that reduces supply-demand imbalances in the labour markets and income disparities among countries, and promotes economic growth (Fakiolas, 2004). Zimmermann (1995) regards the behaviour of immigration as one of the most important issues in the contemporary global economy. It is estimated that over 140 million people now live in a country where they were not born (United Nations, 2002). Therefore, it is important to understand the impacts of international migration under the theoretical and empirical base.

3.3 Economic Impacts of International Migration

Given the significance of immigration for the societies of receiving countries, there are quite a lot of studies have addressed the extent to which immigration has affected receiving countries’ economic growth, the employment and income outcomes of native workers. In general, people worried about the adverse consequences of immigration are usually based on the standard economic paradigm, which would predict that an additional supply of workers into an economy is expected to reduce wages. It also believes that if wages are inflexible, the unemployment rate should rise due to an excess supply of labour, especially if immigrants and native labour are substitutes in production (Pouliakas *et al*, 2008). Longhi *et al.* (2008) stated that economic theory

alone cannot give a decisive answer about the expected impact of immigration on the labour market and local economy. The following sections reviews the previous studies on the impact of international migration on five main economic issues, namely, economic growth, labour market, domestic household, international trade and fiscal consequences.

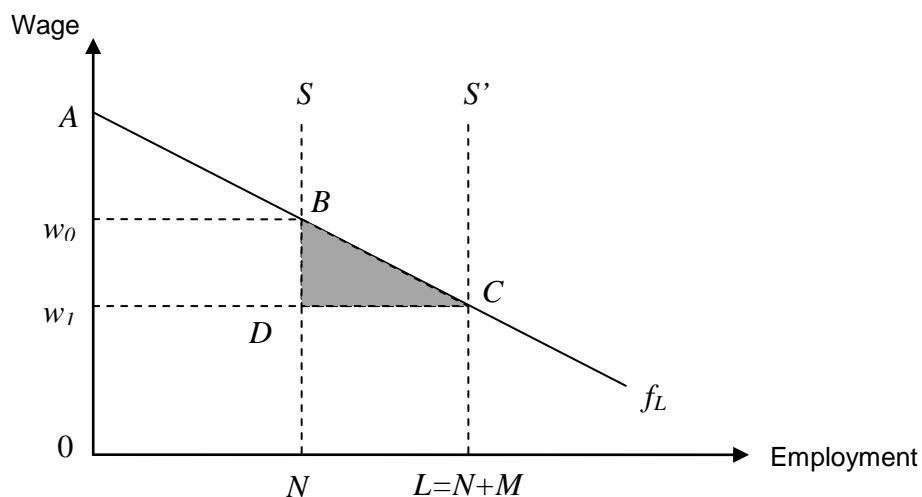
3.3.1 Impacts on Economic Growth

Macroeconomists and international economists are interested in the question of the influence of migration on (per capita) growth, which may be particularly focused on the context of increasing returns to scale. Friedberg and Hunt (1995) find that theoretical work has made strides toward explaining the possible links between immigration and growth, but only a few empirical studies have been conducted.

A simple theoretical analysis of impacts of migration on growth can be based on a modified Solow (1956) growth model. Barro and Sala-i-Martin (2004) made comprehensive discussion on economic growth. There are three basic inputs to the production function of an economy, labour, physical capital and human capital (knowledge). Land, natural resources and so on are not of mobility and do not factor into the equation. Labour and human capitals are internationally mobile, but physical capital is not. They assumed there is no trade between countries. A country receives immigrants if it has a higher ratio of physical capital to labour, which implies a higher wage rate. Assumed that immigrants do not bring physical capital with them, but they do bring human capital and will bring more human capital if the ratio of physical capital to human capital is high. In this model, the key to the impact of immigration is whether immigrants bring enough human capital to offset their dilution of physical capital in the receiving economy. If there is little human capital with immigrants, their impact is similar with faster population growth, and slow down growth. If human

capital levels of immigrants are higher than the local people, economic growth will be accelerated. The main limitations of this theoretical framework are: a closed economy is assumed and the absence of congestion effects.

Figure 3.1 The Immigration Surplus in a Model with Homogeneous Labour and Fixed Capital



Source: Borjas 1999.

Borjas (1999) proposed a simple model with two inputs, capital (K) and labour (L), so that output $Q = f(K, L)$. The labour force comprises the number of N natives and M immigrants, and all workers are perfect substitutes in production ($L=N+M$). Figure 3.2 illustrates the model of a competitive labour market. In the pre-immigration regime, the national income accruing to native Q_N is given by the trapezoid $ABNO$. The entry of M immigrants shifts the supply curve and lowers the market wage from w_0 to w_1 . The area in the trapezoid $ACLO$ now gives national income. The arrival of immigrants increases the GDP of the host country and generates a surplus. This profit to the native economy is equal to the triangle BCD in the Figure 3.2.

Brezis and Krugman (1993) formalize the assumption of increasing returns to scale production in a free trade model where the country receiving immigrants can borrow

and lend at the world interest rate. In this situation, if exogenous immigration occurs, output will increase more than proportionately, which implies a rise in the rate of return to capital as well as an increase in the wage. Due to a higher quantity of labour results in a higher wage in these models, the receiving country's aggregate labour demand curve becomes upward sloping.

Kindleberger (1967) was one of the main advocates of the view that immigration was the main factor behind the remarkable rates of economic growth witnessed in the post-war period in Europe. The impact of migration on growth may be judged in two ways: which including a migration variable affects the estimated convergence coefficient, and also by the actual coefficient on migration, which can be interpreted as the effect of migration on long-term growth. Barro and Sala-i-Martin (1992) include migration in an equation regressing growth in per capita income for Japanese and American regions in different time periods. The result suggests that a 1 percentage point higher net migration is associated with a 0.1 percentage higher growth rate.

There were some other attempts trying to quantify the magnitude of immigration labour effects using fairly simple techniques. Askari (1974) multiplied the annual contribution of labour to growth by the percentage of foreign workers in the labour force and found that the impact of immigrants on growth rates in the EEC was fairly small. The largest effects were found in Luxembourg, where immigrants were estimated to have increased annual growth rates by an average of around 7 percent between 1960 and 1970. The impact of immigrants on the annual growth rates of Belgium, France, Germany and the Netherlands was much smaller since immigrants typically contributed less than 0.05 percentage points. Bourguignon and Gallais-Hamonno (1977) estimated that immigrants contributed around 5 per cent to France's GNP in 1971.

Blattner and Sheldon (1989) take a different approach in that they specify a production

function for Switzerland that distinguishes between domestic and foreign labour. They apply a growth accounting framework to isolate the contribution of immigrants to output growth rates, productivity and per capita GDP. They estimate that foreign labour accounted for around 0.3 percentage points of the 2.7 per cent average growth rates that Switzerland experienced between 1961 and 1982. However, they find that foreign employment had a negative effect on both productivity growth and per capita growth over this period, which they explain by the lower output elasticity of foreign workers, possibly as a result of the jobs in which immigrants are typically found. Taylor (1997) finds that immigration drove down real wages in the country by around 25 per cent and caused a 19 per cent increase in GDP on Argentina over the period 1870 - 1914.

Using an expansion in varieties framework, Brestschger (2001) analyzes the impact of the supply of skilled and unskilled workers on the growth rate in open economies. The author finds that an increase in skilled migration has unambiguously positive effects on growth, while the effects of unskilled migration depend on the elasticity of substitution of skilled and unskilled in both the high tech and the traditional sector. In particular, the smaller the country is, the higher the possibility of negative effects on growth of unskilled migration will be.

The importance of the skill composition of migrants is also stressed by Brucker and Kohlhass (2002) and Pouliakas *et al.* (2008). Brucker and Kohlhass (2002) study the immigration surplus in the context of a general equilibrium model with various degrees of wage rigidities in an open-economy framework, German economy. They conclude that a higher share of highly qualified migrants has higher positive influence on GDP, while a higher share of low-skilled workers could reduce the average productivity and GDP. Pouliakas *et al.* (2008) constructed regional CGE models to analyse the effects of immigration on the economic activity of three EU regions, namely, Scotland, Greece and Latvia. A large number influx of unskilled labour has

the largest positive effect on Greece GDP growth by 4.16 percent and the smallest positive effect on Scotland by 1.78 percent. Nevertheless, the skilled labour immigration has the largest effect on Scottish GDP, but the smallest effect on Greece.

3.3.2 Impacts on Labour Market

In theory, immigration could have a number of impacts on the labour market and in particular the labour market outcomes of natives. Depending on the characteristics of migrants and the labour market adjustment process, impacts could be seen on both employment and wages. What happens when immigration increases the supply of workers in a particular labour market? In his influential introductory textbook, Paul Samuelson (1964, p.552) gave the common-sense answer implied by the standard model of the labour market: “Limitation of the supply of any grade of labour relative to all other productive factors can be expected to raise its wage rate; an increase in supply will, other things being equal, tend to depress wage rates”. Samuelson made the point that immigration restrictions tended ‘to keep wages high’. He also stressed the mirror-image implication: as immigrants increase the supply of a particular type of labour, the wage paid to that group falls.

The theoretical analysis of the labour market effects of immigration sees effects as arising from the changes it introduces in supply of skills and consequent change in labour market equilibrium (Dustmann *et al.*, 2003). Typically a distinction is drawn between skilled and unskilled labour. Immigration inflows affect the skill composition of the labour force if the skill composition of immigrants does not match the already existing skill composition. This change in skill composition leads to disequilibrium between supply and demand of different labour types at existing wages, prices and output levels.

Friedberg and Hunt (1995) suggested that immigrants will lower the price of factors with which they are perfect substitutes, have an ambiguous effect on the price of factors with which they are imperfect substitutes and raise the price of factors with which they are complements. For example, an influx of foreign-born labours reduces the economic opportunities for labours that all labours now face stiffer competition in the labour market. At the same time, high-skill natives may gain substantially. They pay less for the services that labours provide, such as painting the house and mowing the lawn, and natives who hire these labours can now specialize in producing the goods and services that better suit their skills.

Similarly, an immigrant influx of high-skill workers would be expected to lower the wage of competing high-skill workers already employed. This influx could benefit low-skill workers, as the pace of scientific discovery allows quicker and cheaper dissemination of technology products, and may increase the productivity of low-skill workers through the introduction of technology products that are more complementary with the types of skills and services that low-skill workers offer to employers. Moreover, although workers including immigrants in total employment will increase, the decrease in wages for them would lead to some natives to leave or reduce their working time, as well as the employment rate of natives may decline. On the contrary, the employment rate of any group whose wage rises as a result of immigration is likely to increase.

Borjas (2003) examined the link between immigration and the evolution of wages for specific skill groups in the past few decades. His study indicates that by analyzing national trends in the labour market and by defining skill groups in terms of both educational attainment and work experience, one can make substantial progress in determining how immigration alters the employment and earnings opportunities of native workers. He assumed that the economy-wide production function can be represented in terms of a three-level Constant Elasticity of Substitution (CES)

technology, a specification that aggregates across different levels of work experience and education groups in order to form the national workforce. In this framework, similarly educated workers with different levels of work experience are aggregated to form the effective supply of an education group; and workers across education groups are then aggregated to form the national workforce.

The assumption that the aggregate economy can be represented in terms of a three-level CES production function greatly reduces the number of parameters that need to be estimated. In particular, there are now three different responses of interest: how immigration in a particular skill group (say high school graduates with 20 years of experience) affects the earnings of native high school graduates with 20 years of experience; how these immigrants affect the wage of younger and older high school graduates; and how these immigrants affect the wage of workers in different education groups.

The evidence from Borjas (2003) suggests an immigration-induced 10 percent increase in the number of workers in each skill group has the following effects: it reduces the wage of native workers in that same skill group by 3.5 percent; it reduces the wage of native workers who have the same education but who differ in their experience by 0.7 percent; and it increases the wage of native workers with different educational attainment by 0.5 percent. The implications of these estimated own- and cross-wage effects for the wage structure are best illustrated by using a particular example. In particular, consider what happened to the earnings opportunities of native workers as a result of the immigrant influx that entered the United States between 1980 and 2000.

It is instructive to illustrate the link that exists between the mean weekly earnings of workers in a particular skill group and the respective immigrant. Borjas (2006) found a negative relation between wage growth and immigration: weekly wages grew fastest for workers in those skill groups that were least affected by immigration. In fact, the

negative correlation implicit in the graph implies that a 10 percent increase in the size of the skill group reduces weekly earnings by about 4 percent.

The majority of existing researches of the impact of immigration on labour market outcomes are based on the data from the U.S., while British evidence is rather scarce. By using the multi-level CES production function approach and covering the UK data during the period from the mid 1970s to the mid 2000s, Manacorda *et al.* (2010) find that native-born and immigrant workers in the UK are far from perfect substitutes in production. They suggest that the overall effect of increased immigration on the wages of natives is little discernible but on the wages of existing immigrants is sizeable.

3.3.3 Impacts on Domestic Household

In academic immigration research, economists also focus on how immigration affects aggregate welfare of the ‘politically relevant’ group of natives, i.e. those who ultimately shape domestic immigration policies. In order to protect native workers from the unemployment or the wage reductions, many countries often restrict the entry of international immigration. Just like trade barriers, immigration barriers are designed to protect natives from foreign competition. It has been argued that these barriers would promote a more equal distribution of income among natives, especially the adverse effects of immigration on the welfare of unskilled workers. However, contrary to popular belief, Chang (2007) thought these concerns for distributive justice do not provide a sound justification for our restrictive immigration laws. Felbermayr and Kohler (2007) showed their optimism that immigration yields a positive aggregate welfare effect in the host country, based on a complementarity relationship between immigrants and some domestic factors

There are two different points of the effects of immigration on native welfare based on

the changes of domestic labour wages found by economists. On one hand, some economists claim that immigration has had a significant adverse impact on the least skilled native workers. DeNew and Zimmermann (1994) estimated that a 1 percent increase in the share of foreign labour caused a 4.1 percent fall in the average hourly wage of all German workers. Steinek (1996) looked at the influence of the migration phenomenon on native welfare by a comparative-static factor market analysis, such as the aggregated effects and distribution among natives. He showed the presence of clear negative effects of migration for the welfare of the domestic population. Under the assumption that immigrants on average on less capital per capita than natives, immigration slows down technological progress as well as the rate of growth of the economy (Drinkwater *et al*, 2003).

Borjas (2003) divides workers into 32 classes based on levels of education and experience. Based on his study, immigration increased the labour supply of working men by 11 percent in the US between 1980 and 2000. His analysis implied that this immigrant influx reduced the wage of the average native worker by 3.2 percent. In different education groups of labour, the wage impact differed dramatically, with the wage falling by 8.9 percent for high school dropouts, 4.9 percent for college graduates, 2.6 percent for high school graduates, and barely changing for workers with some college (Borjas, 2003).

On the other hand, some economists argue that immigration would increase the average wages of native workers. Chang (2007) placed his suspicions on Borjas's negative effects of immigration. He argued that the influx of immigrants into the US included workers from all 32 classes of labour and many of these workers may be complements rather than substitutes for native workers in any given class of labour. He also doubted the assumptions Borjas used in his analysis. First, Borjas assumed that immigrants were perfect substitutes for natives within each class of labour. Second, Borjas assumed that the capital stock was fixed and did not respond to this

immigration by increasing the supply of capital to the economic activities employing this expanded supply of labour. Therefore, Chang (2007) argued that Borjas's simulation was inherently biased in favour of finding large adverse effects on native workers.

Firstly, skilled immigrants not only increase total wealth for natives but also promote a more equitable distribution of income among natives (Chang, 2003). They might have a negative effect on competing skilled natives. However, other types of labour, including less skilled natives, would enjoy the benefits of increasing real wages. Therefore, unskilled immigration, which could have an adverse effect on the real wages of unskilled native workers, would be justified for a more equal distribution of income. Borjas (1999b) suggested that if increased immigration lowered the wages of unskilled native workers, more natives would invest in human capital for acquiring more skills. On this way, the supply of unskilled native workers would decrease and the supply of skilled natives would increase, which would in turn reduce income inequality among native workers.

Secondly, there was little evidence of any significant effects of immigration on native wages or employment, even for the least skilled native workers (Friedberg and Hunt, 1995). In view of the small effects of immigration on local wages and employment, protectionist policies seem particularly misleading. By researching the effect of the Mariel Cubans on the Miami labour market, Card (1990) found that the dramatically influx of labour had virtually no effect on the wages and employment opportunities for works in Miami, including unskilled whites and unskilled blacks. The reason is that the demand for labour does not remain fixed when immigrants enter the economy. Immigration not only supplies labour, they also demand goods and services, and this demand will translate into greater demand for locally supplied labour. This increase in demand can offset the effect of increased supply (Chang, 2007).

Furthermore, Grossman (1982) indicates that immigrants and natives are not perfect substitutes in the labour market, so they often do not compete for the same jobs. In fact, the jobs of immigrants and native workers are different. Due to similar characters, immigrants tend to compete with other immigrants far more than they compete with natives. Indeed, some immigrant labour can be a complement rather than a substitute for some native labour, so that an increase in the supply of immigrant labour will increase the demand for native labour and thus have positive effects on native wages rather than negative effects (Borjas, 1999b). Additionally, immigrants are often willing to do jobs that locals no longer are interested in, such as care for the elderly (UNDP, 2009). Also, the availability of low-cost childcare by the immigrants can enable young local women to go back to work (Kremer & Watt 2006) thus boosting economic development further.

In order to prove these points, Chang (2007) considered the restaurant business as a simple example. Suppose restaurants employ both waiters and busboys, and an influx of immigrant labour expands the supply of busboys. Because of strength of language skills, restaurants prefer to hire native as waiters. Therefore, immigrants and natives are complementary rather than substitution in this labour market. Natives may dominate the jobs of waiter, whereas immigrants may mainly work as busboys. Chang (2007) believed that the expansion in the supply of busboys reduces their wages and thus cuts a restaurant's labour costs, which enables it to charge lower prices while still enjoying an increase in its profits. Moreover, lower prices would bring in more business, and more immigrants would also consume more goods and services in local market.

With the purpose of profits maximum, restaurants' owners will invest in more capacity to handle the increasing volume of business, and they must hire more waiters. As a result, the increased demand for waiters drives up the wage of waiters, who tend to be native workers. Given the expanded demand for waiters, perhaps natives previously

employed as busboys can now get better employment with higher income as waiters. Native workers employed as waiters enjoy more benefits from the entry of more busboys because these two groups of workers are complements in production.

This example shows the positive effects of immigrants on unskilled native workers. On the contrary, cutting off immigration would have the opposite effects (Chang, 2007). Immigration restrictions may increase the wages of some workers, but these workers are more likely to be other immigrants rather than natives. Higher labour costs would lead to shrinkage of workers employed in those sectors, which would directly reduce the work opportunities to natives. Furthermore, if some of the products of these sectors are in the international trading market, then the higher labour costs may cause these jobs to go overseas, where the labour is more abundant and lower cost. Therefore, the end result of immigration restrictions is likely to be harmful to local workers.

Ottaviano and Peri (2005) found different results that all immigration into the US from 1990 to 2004 increased the average wage of native workers by 1.8 percent and decreases the wage of native high-school dropouts by only 1.1 percent. They used a simulation that allowed the supply of capital to adjust and allowed immigrants and natives within each class of labour to be imperfect substitutes. Indeed, they found that all native workers with at least a high-school education enjoyed increased wages as a result of this immigration rather than reduced wages. Thus, this influx of immigrants had an adverse effect only on the shrinking minority of native workers with less than a high-school education, and this effect was quite small. Many of these workers may well enjoy net gains rather than suffer net losses as a result of this immigration.

3.3.4 Impacts on International Trade

Both trade liberalization and labour free movement are hot topics in recent

globalisation issues. Lots of policymakers are inconsistent in advocating free trade or relaxing the restriction on immigration policy. It has been widely agreed that the effects of free movement of people are quite different from the free trade of commodities. However, the reality shows that some rich countries are reluctant to open their borders to migration after creating a free trade area (Wellisch and Walz, 1997). By using a two-country Heckscher-Ohlin-Samuelson (HOS) model with unskilled and skilled workers, Schiff (1998) concludes that the developed countries always gains by controlling immigration and the developing countries by freeing trade. Davis and Weinstein (2002) also explain why free trade might be preferred to free migration by using a Ricardian model where the one country is technologically superior in all sectors. With free trade, the country has a monopoly power over its own technology, but migration would bring the technology abroad and lessen this monopoly power.

Economic models suggest that immigration and trade alter national output in the host country by increasing the country's supply of relatively scarce factors of production (Borjas 1999). As a result, the economic incentives, which motivate particular types of workers to migrate to a host country, motivate those same workers to produce goods that can be exported to that host country. According to the HOS model, the effect of immigration on an open economy will depend on the relative prices of traded goods (the *Stolper-Samuelson theorem*, 1941), or, given relative prices, on relative factor endowments (the *Rybczynski theorem*, 1955), which will ultimately determine the optimal output-mix in the economy (Pouliakas *et al*, 2008). Therefore, the effects of an increasing labour supply to an economy can be regulated by changes in the volume and structure of international trade and production. A key distinction between immigration and trade is that natives can escape some of the competition from abroad by working in the non-traded sector. Immigrants, however, can move between the traded and non-traded sectors, and natives cannot escape competition from immigrant workers (Borjas 1999).

Similarly, Razin and Sadka (2000) and Schiff (1996), by relaxing some of the HOS assumptions, show that free trade might not be a substitute for migration. Ambiguous effects derive from the relaxation of the constant returns to scale and the identical technologies assumptions. Economies of scale external and internal to firms can generate complementarities between movements of commodities and movements of people. Similarly, if technologies are assumed not identical, factor mobility and commodity trade might complement each other. Razin and Sadka (2000) suggest that complementarity between migration and trade results from a HOS model with migration costs and financing constraint. In this framework, complementarities are more likely the lower the skills and income of potential migrants.

The complementarities between trade and migration follow from the presence of positive externalities, namely agglomeration economies, between individuals' (consumers or workers) and firms' location decisions (Drinkwater *et al.*, 2003). The assumption of increasing returns at the level of the firm and transportation cost are at the basis of the so-called New Economic Geography (NEG) models, which is developed to explain the agglomeration of economic activity (Rosenthal and Strange, 2001). Krugman (1991) shows that the interactions of labour migration and the assumptions of increasing returns and trade costs, create a tendency for firms and workers to cluster together as areas integrate. Agglomeration into the 'large' region is driven by scale economies, namely plant fixed costs of production and scale economies through the scale benefits of a larger market. The complementarity between trade and migration follows from the process of cumulative causation. In particular, the increase in the number of firms in one region determined by a decrease in trade costs, makes that region more appealing for individuals (i.e., higher wages and increase in the number of local varieties) and it generates the above mentioned process of cumulative causation (Drinkwater *et al.*, 2003). Therefore, by adding imperfect competition, trade liberalization affects the location choices of individual and firms.

Apart from the theoretical consideration, there are a number of recent empirical studies have found that immigration has a positive effect on trade between the immigrants host and home countries (Gould, 1994; Dunlevy and Hutchison 1999; Girma and Yu, 2000; Wagner *et al.*, 2002; Poot and Cochrane, 2005). Girma and Yu (2000) identified two basic reasons for this effect. Firstly, immigrants tend to have a preference for the products from their home countries, as a matter of taste or due to emotional attachment. Secondly, immigrants can reduce transaction costs of bilateral trade with their home countries either through individual characteristics such as business contacts or through more generic traits such as language. The first of these explanations should only result in an increase in the host country's imports, whereas both imports and exports would be expected to increase as a result of the second explanation. Transaction costs could be reduced through a number of channels:

- 1) trade can be enhanced through the diminution of communication barriers resulting from immigrants being able to converse with co-linguals in their home country;
- 2) immigrants can also bring with them information about home country products if these are differentiated from those of the host country and hence the cost of obtaining this information will be reduced;
- 3) the development of trust through immigrant contacts can also reduce the costs of negotiating and enforcing trade contracts.

Although international immigration has positive effects on trade, it is important to distinguish the effect on imports from the effect on exports (Poot and Cochrane, 2005). Ching and Chen (2000) found that migration from Taiwan to Canada had a greater impact on imports into Canada than on exports. Using Swiss data, Kohli (2002) also found that immigration tends to stimulate imports and to shift the output mix towards non-traded goods, thereby impacting negatively on the trade account. In another study on Canada, Wagner *et al.* (2002) found that the effect of the average new immigrant on imports is three times than on exports. On the whole, the elasticity of the effect of

immigration on imports is larger than the elasticity of the effect on exports.

Empirical studies typically use a gravity equation of trade augmented by immigration data to measure the size and direction of the trade-immigration relationship (Drinkwater *et al.*, 2003). Gould (1994) analysed the impact of immigration on trade between the US and 47 trading partners between 1970 and 1986. He suggested that the immigrant information effects appeared to be stronger for imports and exports of consumer manufactures than for producer goods and that exports are influenced by immigrant links to a greater extent than imports. Head and Ries (1998) employed a similar methodology to investigate the effect that immigration has on Canadian trade patterns and also find a significant relationship between trade and migration flows. Furthermore, Wagner *et al.* (2002) estimated that the average new immigrant for Canada increased exports to their own country by \$312 and increased imports by \$944.

When investigating the relationship between immigration and trade using U.K. data, Girma and Yu (2000) found different results depending on whether immigrants originate from Commonwealth or non-Commonwealth countries. Immigration from non-Commonwealth countries had a significant effect on export-enhancing, but no significant effect was found between immigration from Commonwealth countries and exports. They find that a 10 per cent increase in the immigrants from non-Commonwealth countries increases bilateral UK exports by 1.6 per cent and imports by 1 per cent in their static models. However, they do not find any significant relationship between immigration and trade for Commonwealth countries. They interpret these findings as supporting the view that immigration reduces the transaction costs of bilateral trade as a result of the immigrant specific knowledge of foreign markets and social institutions rather than through the personal or business contacts that immigrants may retain with their home countries. Dunlevy and Hutchison (1999) also provide historical evidence in favour of the positive impact that immigration had on imports into the US around the turn of the twentieth century.

3.3.5 Impacts on Tax Revenue and Public Expenditure

By changing labour supply, international immigration may alter a country's fiscal accounts. In order to examine the fiscal impact of immigration, the amount received in immigrant tax receipts should be compared with social welfare payments to immigrants (Drinkwater *et al.*, 2003). The literature on fiscal consequences of international immigration on receiving countries contains both positive and negative effect points. With progressive income taxes and means-tested entitlement programs in many receiving countries, positive fiscal consequences from immigration would appear to be more likely the more skilled labour inflow (Hanson, 2008). In contexts where immigrants pay less in taxes than they receive in government benefits, immigration increases the net tax burden on natives, necessitating an increase in taxes on natives, a reduction in government benefits to natives, or increased borrowing from future generations.

By and large, the fiscal impact of international immigration is positive, as immigrants add more to tax revenue than to government consumption or social security payment. Therefore, immigration reduces the net tax burden on native taxpayers. Lalonde and Topel (1997) survey US evidence and report that immigrants are net contributors, although most of this evidence relates to the 1970s, since when average immigrant skills have decreased and hence a larger proportion are below the poverty line. Gott and Johnston (2002) also suggest that immigrants make a positive net contribution to the UK economy. They estimate that in 1999/2000, immigrants to the UK contributed \$31.2bn in taxes and received \$28.8bn in benefits and state services.

On the contrary, Smith and Edmonston (1996) estimated that in 1996 immigration imposed a short-run fiscal burden on the average US native household of \$200, or 0.2

percent of U.S. GDP. In that year, a back of the envelope calculation suggests that, the immigration surplus was about 0.1 percent of GDP, meaning that immigration in the mid-1990s reduced the annual income of US residents by about 0.1 percent of GDP (Borjas, 1999b). Canova and Ravn (2000) examined the macroeconomic consequences for West Germany of German unification using a dynamic general equilibrium model. They argued that this event is similar to a mass migration of low-skilled workers holding no capital into a foreign country. In the absence of a welfare state, West to East transfers raise distortionary tax rates and result in an investment boom and depressed output. With the welfare state the investment boom disappears and the recession is prolonged.

Sinn (2002) focused on the potential adverse fiscal consequences of migration that may result from EU enlargement. If migration occurs as a result of the welfare programmes offered by Western countries, then this could create competition between these countries to deter Eastern migrants from entering. The concern is that enlargement to include lower income countries in Central and Eastern Europe will lead to low-skilled migration to higher income countries, and increases in welfare usage. To prevent this from occurring, Sinn (2002) recommended the harmonisation of welfare systems, selective migration policies or limiting the access of migrants to the welfare system.

Furthermore, Poot and Cochrane (2005) suggested that the standard approach to the fiscal impact of immigration in the international literature consists of combining a demographic profile of the population before and after an immigration influx with the cost per capita of providing public consumption and transfer payments. Similarly, tax revenues are estimated based on the incomes and consumption patterns of different demographic groups. The main cause of the positive net impact is the age profile of immigrants. They tend to be relatively young, and often also single. Given the very strong links between age and the major public expenditure items of health and

education, immigration tends to increase education expenditure and lower health expenditure, with the net balance being a reduction in total expenditure.

However, there are also dynamic fiscal effects from immigration. Drinkwater *et al.* (2003) recommended that intergenerational considerations should be taken into account, and if this is done the contribution made by immigrants may be an underestimate since second generation immigrants are also likely to be net tax payers. Lee and Miller (2000) also noted that the only meaningful calculation is longitudinal, tracing the consequences of an immigrant's arrival through subsequent years, and taking full account of all the immigrant's descendants. Taking such a longitudinal perspective, they found with US data that the Net Present Value of the fiscal impact of an additional immigrant starts out negative, and then turns positive within the first 25 years and keeps on increasing from then on. Gustafsson and Österberg (2001) also found that upon arrival in Sweden immigrants did generate a net burden on the public sector budget, but this was reversed after a few years. Refugees initially put a larger burden on the public sector budget, but the difference with other immigrants declines over the years.

In addition, if the net tax burden on residents of a country is expected to increase in the future, immigration increases the tax base over which this burden can be spread and reduces the increase that natives would have to bear (Collado *et al.*, 2004). But this is only true if the descendants of immigrants see their incomes rise to a point where they make positive net tax contributions. If the children of immigrants have their educational attainment lag behind that of natives, high levels of immigration today could instead increase the future tax burden on the native population.

If immigrants are primarily individuals with low incomes relative to natives, increased labour inflows may exacerbate distortions created by social-insurance programs or means-tested entitlement programs, making a departure from free immigration the

constrained social optimum (Wellisch and Walz, 1999). In view of its aging population and unfunded pension liabilities, one might expect Western Europe to be opening itself more aggressively to foreign labour inflows. However, concerns over possible increases in expenditure on social insurance programs may temper the region's enthusiasm for using immigration to solve its pension problems (Boeri and Brucker, 2005). Therefore, tax and transfer policies create a motivation for a government to restrict immigration, even where the level of immigration is set by a social planner (Hanson, 2008).

In the US, the fiscal consequences of immigration appear to matter for immigration policy preferences. Hanson *et al.* (2007) found that US natives who are more exposed to immigrant fiscal pressures, those living in states that have large immigrant populations and that provide immigrants access to generous public benefits, are more in favour of reducing immigration. This public-finance cleavage is strongest among natives with high earnings potential, who tend to be in high tax brackets. Facchini and Mayda (2006) obtained similar results for Europe. More educated individuals are more opposed to immigration in countries where immigrants are less skilled and governments are more generous in the benefits they provide.

3.4 Other Impacts of International Migration on Sending and Receiving Countries

Not only does international migration have the economic effects on receiving, but also have other multifold impacts on both the sending and the receiving countries. Table 3.1 has provided a comprehensive summary of micro and macro impacts of immigration in both short-run and long-run.

Table 3.1 Important dimensions of the Economic Impact of Immigration

	SHORT-RUN	LONG-RUN
MICRO	Initial migrant wages and employment Relative wages between and within migrant and native groups Discrimination in the labour market Housing Effects on other consumption: food, transportation, etc. Migrants' post-settlement human capital investments Social security Business investment Saving behaviour	Labour market flexibility Business practices Innovation and entrepreneurship Migrant adaptation and 'catch up' Migrant geographical and social clustering Social mobility across generations Migrants' net fiscal balance over the lifecycle Remittances and international networks
MACRO	Population size, composition and geographic distribution Capacity utilisation, the business cycle and expectations National and sectoral accounts Health and education expenditure, fiscal balance International balance of payments Unemployment Aggregate wage level Inflation Interest rates Income distribution Congestion and utilisation of public infrastructure	Fertility and population ageing Real income per head and the long-run rate of economic growth Sectoral composition of the economy Public and private infrastructure Technological change Economies of scale Total factor productivity Foreign debt Public debt International trade patterns Social cohesion, cross cultural relations and crime The environment

Source: Poot and Cochrane, 2005.

To classify the various types of impact, it is important to distinguish between a short-run and a long-run perspective. This distinction in Table 3.1 between short-run and

long-run is not entirely clear cut and will vary with the context. In addition, short-run fluctuations can have permanent effects, such as a long-term disadvantage to migrants that may arise from their arrival in times of recession (Aydemir 2003). A distinction must also be made between macro level and micro level effects. The combination of macro versus micro and short-run versus long-run effects leads to a two-way classification that is helpful to categorize the various types of economic impact (Poot and Cochrane, 2005).

Coppel et al. (2001) identified four major consequences of international population movements.

- 1) There is the effect that immigration has on the host country's labour market. Although the possible adverse effects that immigration can have on the wage and employment levels of natives are typically examined, immigration may also have a role to play in reducing skill shortages in certain key sectors of the economy.
- 2) Immigration is likely to influence the budgetary position of the host country since the amount recent arrivals receive through health, education and welfare systems is unlikely to exactly balance the increased tax revenues from new workers.
- 3) It is argued that immigration may be a solution to the ageing population problem that faces many OECD countries. In fact, this is closely related to the first point – labour market.
- 4) Immigration can have a major economic impact on the source country. These effects can either be negative, in terms of brain drain, or positive since migrants' remittances are thought to be an important economic development tool for many labour exporting countries. As a result, the general balance of

these effects is likely to have a main influence on immigration policies that are implemented, both in the home and host countries.

The following two parts will review the positive and negative effects of international immigration on detail.

3.4.1 Positive Effects of International Immigration

Socialists believe that migration is part of social evolution. Migration is not always a positive sum game in which both the sending and the receiving countries stand to gain, especially if the intangible and long-term effects are taken into account (Fakiolas, 2004). For many migration movements, there may be the overall positive effects in both the receiving and the sending countries appear to exceed the negative ones, while there are others that have more negative effects. There are several positive effects of international immigration, namely, international immigration has positive effect on improving the quality of population; they will promote the economic development of receiving countries by increasing population and employment; they make contribution to urban development; they have important impacts on receiving countries' culture; the remittances they send will increase home countries' foreign saving and investment ability. In order to gain some better and clear understanding, it may be necessary to further calibrate those points in some detail.

Firstly, it is believed that international immigration has positive effect on improving the quality of population. On the one hand, population mobility is conducive to avoid inbreeding marriages, or just in smaller groups and geographical area marriages. The latter is inevitable in an isolated agricultural society. On the other hand, the process of migration will keep the best but eliminate the worst. Especially in the early time and long-distance migration, people who are able to reach the destination and survive are

mostly both physical and intellectual superiority. People migrated frequently are more open to new ideas, new concepts and new technologies (Lu, 1997). For example, as ‘states of migration’, the United States is a young country with full of vigour and vitality. Thanks to immigrants’ pioneering and adventure spirits, the United States becomes a prosperous and highly developed country. Canada is an immigrant country as well, which receives about 300 thousand worldwide immigrants every year. Therefore, like the United States, Canada also shares immigrants’ knowledge, skills, traditions and achievements.

Secondly, international immigration has positive impacts on the economic development of receiving countries. It is commonly accepted that immigration can help in alleviating labour shortages in various countries (OECD, 2001). There are many reasons causing the shortages of unskilled labour, for example, the aging of the population, increasing school attendance and the decline in the rural out-migration in developed countries. New native labour force entrants aspire now to more “dignified” jobs than that of the factory or construction worker or the peasant farmer (King *et al*, 1999). On the other hand, the market demand for low-skilled labour remains high in agriculture, construction and some services, despite rapid mechanization and automation (Fakiolas, 2004).

Similar to shortages in low-skilled labour, developed countries are also lack of skilled labour. Therefore, the immigrants with higher production knowledge and skills will help the receiving countries to solve this kind of shortage, and then promote economic and social development. As some scholars have recognized that the US economy relies heavily on the foreign-born scientists and engineers (Duignan and Gann, 1998).

Furthermore, highly skilled immigrants help the receiving countries to save a lot of education and training costs. In the United States, there were about 42 percent of foreign-born adults have higher education, and about 23 percent of these people have

Master's degree (Robert, 2005). It is estimated that American college students spend about 100 thousand dollars to obtain Bachelor's degree, and need 50 thousand dollars to a Master's degree after graduating from university, and then at least another 50 thousand dollars for PhD degree. In other words, a Master's degree student needs a total cost of 150 thousand dollars, and PhD costs more than 200 thousand dollars (Peter and Lewis, 1998). Those highly educated labour forces not only provide a rich pool of labour sources, but also saved a considerable amount of education and training fees for US economy.

Immigration also makes contributions to receiving countries' economic and technological development. The immigrants from Asia and South America have been considered as the backbone of the US economy. One study showed that both legal and illegal immigrants are not the burden of the US economy. On the contrary, they annually make about 10 billion dollars worth contribution to the US economy. In Silicon Valley, many companies are run by Indians or Chinese. There are about 100,000 Indian Information Technology professionals obtain 6-year special temporary visa to work in the US. The Indian-American has reached more than one million people, about 80,000 to 100,000 live in the Washington area, and most of them work in the high-tech intensive district. In 1999, about 300,000 Indian-Americans have jobs in high-tech companies located in California's Silicon Valley, and their total incomes are up to 60 billion dollars (Li, 2007). Many Chinese also entered the world famous Silicon Valley and have made important contributions to high-tech development. Messina and Lahav (2006) thought it is very difficult to accurately estimate the economic impact of immigrants. However, the very important fact is that all immigration policies are based on these assessments.

Thirdly, international immigration plays a very important role in population growth and employment. A country's population growth depends on two factors: domestic natural growth and the influx of immigrants. During the period from 1990 to 1995,

about 45 percent of population growth in more developed regions was from international immigration. For example, in Canada, the US, Australia and New Zealand, the immigrants accounted for one third of population growth; in European countries, 88 percent of increasing population came from international migration. At the same time, international migration caused population growth rate in less developed regions dropped by 3 percent, such as the population growth rate in Latin America and the Caribbean fell by 7 percent (Li, 1997).

There are many studies focusing on the subject that the impacts of immigration on the economy and employment. There is an indisputable fact that international migration will relieve the population growth pressure in developing countries, and give more employment opportunities to emigrants. However, there is a controversial issue that if immigrants harm the host countries' labour market or not. Duignan and Gann (1998) thought that immigrants are cheap labour which compete jobs with national people. Some economist found that labour immigration has little effect on domestic employment that slightly reduces the employment opportunities of low-skilled workers (Engerman and Gallman, 2000). They found several reasons. First, immigrants have created new employment opportunities. Due to the sustainable development of industry promoted by immigration, the demand for goods increases, and then creates new job opportunities. In addition, due to the lack of language, education and work experience, the new immigrants have very little competition with national workers. Some studies support that immigrants have little impact on local wage level (Card, 1990; Friedberg and Hunt, 1995; Chang, 2007). Finally, immigrants including illegal immigrants pay taxes to the government more than their income from the government. In 1980s, a research showed that about 11 million immigrants had 240 billion dollars annual income, and paid taxes at more than 90 billion dollars which was far more than the social welfare they gained at 5 billion dollars in the US (Chen, 2002). In a word, immigrants are the wealthy of the United States rather than a burden.

Fourthly, international immigration makes contribution to the urban development. As urban area has more employment opportunities than rural area, many immigrants are more willing to live in cities, and then develop cities, such as New York, Vancouver, Hong Kong and Singapore. Immigration is an important driving force in New York geographic and population expansion. Different from London, Paris and Tokyo, immigrants are major source of New York population growth. From 1820 to 1920, there were 11.3 million immigrants have entered New York, reached the highest proportion of total population at 50 percent (Duignan and Gann, 1998). Influx of immigrants stimulated urban infrastructure growing rapidly, such as housing, schools, hospitals and stations, and also increasing the number of factories and shops. During that century, New York population increased by nearly 50 times and the area increased by 80 times. Large number of immigrants built up New York's prosperity and success, which in turn helped New York to attract more foreign immigrants.

Fifthly, international immigration is conducive to cultural exchange and transmission. For example, large-scale international migration into Latin America, and different races and ethnic groups lived with each other. These immigrants brought their own language, religion, culture and art to Latin American. After a long period mutual interaction and adaption process, and finally formatted a new Latin American culture. Nowadays, it can be found the impacts of different cultures, such as European culture, African culture and Oriental culture, on all fields of contemporary Latin American culture (Xia, 1992).

Canada is the second largest population immigration destination, just after the US. The immigrants in Canada come from more than 150 countries and regions currently. From 1981 to 1991, there were about 1.3 million immigrants into Canada, which contained immigrants from Europe for 26.4 percent, while the proportion of immigrants from Asia was up to 46.5 percent. In order to implement multicultural policies, the government of Canada through the "Human Rights" in 1976, "The Charter of Rights

and Freedoms” in 1982, and House of Representative passed “Canadian Multiculturalism Act” in 1988. These policies are beneficial for the integration and development of multi-culture.

Sixthly, not only the remittances from emigrants benefit their own families, but also increase their home countries’ foreign exchange and investment capacity. Given that inadequate capital and entrepreneurship do not allow most developing countries to create enough employment opportunities for all their labour resources, emigration will help them to ease the high pressure of supply in their labour markets (Fakiolas, 2004). At the same time the inflow of the emigrant remittances significantly raises the living standards of the emigrant families. The economic impact of remittance is enormous. According to the statistics of the International Monetary Fund, foreign workers send money back to their home countries at about 75 billion dollars, which is about 50 percent more than total official development assistance (Massey, 1998). By 2005, worldwide remittances exceeded 232 billion dollars, which developing countries received 167 billion dollars. The valuable foreign exchange also let the sending countries to import the necessary capital goods for their economic growth and to implement basic social policies (Fakiolas, 2004).

Choucri (1999) shows that once the process of emigration is set in action, its consequences on unemployment, earnings, consumption, savings and remittances are felt throughout the economy. In the medium and longer term some emigrants will return back and develop entrepreneurial activities in their home countries, usually with the use of their accumulated savings. For example, since 1980, thousands of Chinese emigrants made foreign direct investment (FDI) to China, and accelerated the development of China’s economy. Similarly, some of the unskilled emigrants who acquire skills abroad also come home and use them at home. It is just like a rule that most first-generation emigrants maintain close ties with their motherland and make contribution to its economic, educational and political life.

3.4.2 Negative Effects of International Immigration

There are some negative impacts of international immigration on both sending and receiving countries. For sending countries, labour outflow would cause negative effects on economic development, and even result in brain drain. For receiving countries, international immigration may cause some economic and social problems, such as decrease of real wage, refugees, illegal immigration and transnational crime.

Firstly, the loss of a large part of their most active, industrious, enterprising and ambitious young people may result a constraint for sustainable growth (Fakiolas, 2004). If the emigrants are either unemployed or low productivity, the opportunity cost of emigration for sending countries is zero or very low. However, it tends to be very high if they are employed in jobs that cannot be filled by others, whatever their skill requirements. For instance, about one third of labour force in Greece and Italy find it can be difficult to achieve sustainable economic development, despite the large amount of foreign exchange that flows into their countries (Sarris and Zografakis, 1999). The situation can be worse that more and more skilled labour are attracted to emigrate for high salary. Therefore, although these emigrants keep sending money back, the remittances do not suffice to compensate for its adverse effects.

Secondly, the loss of scarce skills through emigration may cause a brain and skill drain in some countries. Appleyard (1999) pointed out that shortages of professional and skilled labour in many developing countries have been aggravated by the emigration of qualified nationals to more developed countries. Africa, Russia, Germany and China are countries or regions that have more phenomena of brain and skill drain. The Russian Federation has lost many people through emigration and, in addition, appears to have suffered from a serious brain and skill drain since 1990. From 1994 to 1996,

college-educated immigrants from Russia to Canada, the US, Israel, Greece and Germany, took the total Russian emigrants at approximately 50%, 45%, 34%, 25% and 17% (Zhou and Bai, 2006). China also faced very serious brain drain. After 1989, many western governments allowed Chinese students and scholars to stay for a period. As a result, there were about 50 thousand Chinese students and scholars to stay in the US, more than 10 thousand obtained the right to work in Canada, and 20 thousand stayed in Australia (Zweig and Chen, 1995). The phenomenon of brain drain is the inevitable process of economic globalisation. However, this kind flow is mainly from developing countries to developed countries. Because of brain drain caused by international immigration, Collinson (1993) thought that sending countries would benefit less from immigration than receiving countries.

Thirdly, there are some potential negative economic effects of international immigration on the receiving countries. Fakiolas (2004) believed that easy access to cheap immigrant labour may diminish the efforts of the receiving country to increase investment in real capital, new technology and the human factor, in order to make its economy more efficient. This would adversely affect the attitudes of national worker by restricting increases in real wage. The argument against the use of low-paid immigrant labours because they would prevent the necessary restructuring in certain industries, which is indispensable to keep them competitive (Brochmann, 1996). Although limited, there is also immigrant-induced unemployment and a downward pressure on the real wages of the unskilled, causing adverse distributional effects on income. Most studies have found that immigrants have negative impact on the wages and employment of natives, although it is not significant. For example, DeNew and Zimmermann (1994) estimate that a 1 percent increase in the share of foreign labour caused a 4.1 percent fall in the average hourly wage of all German workers. Card (1990) for Miami, and Hunt (1992) for France also find that the inflow of immigrants had effect on the wage and employment levels of natives.

Fourthly, the negative impacts of international migration contain the problems of refugees, illegal immigration and transnational crime for receiving countries.

- 1) Immigrants, especially the influx of refugees exacerbated tensions and increased instability in some regions. Since 1976, the refugees around the world increased at an annual growth rate of 12 percent, and put heavy economic burden to receiving countries. The U.S. Committee for Refugees and Immigrants gives the world total as 62 million refugees. As of December 31, 2005, the largest source countries of refugees are Afghanistan, Iraq, Myanmar, Sudan, and the Palestinian Territories (Wikipedia, 2009).
- 2) The influx of illegal immigrants would cause the problems of housing and employment in short term, and then exacerbate local social conflicts. According to the conservative estimation from International Organization for Migration (IOM), there were about 150 million international migrants worldwide, for which 40 million were illegal immigrants. Illegal immigration would gradually damage the objective of legal immigration program in receiving countries. In particular, it has effects on local fiscal planning, wages and employment opportunities (Djajic, 2001). In addition, illegal immigration has a profound impact on international relations. As different countries have different views and treatments on illegal immigration, they might blame each other and evade responsibility.
- 3) International immigration causes transnational crimes, which directly threat the peace of world and hinder the development of world economy. September 11th, 2001, the world was shocked by the '9.11' terrorist attacks in the US. Terrorists hijacked four airplanes, two of which crashed into the World Trade Centre in New York, one hit the corner of the Pentagon, the last one crashed down. It has been proved that the terrorists enter the US through a variety of legal or illegal ways. This issue made huge loss on US economy and created an unstable situation in the world.

3.5 Analytical Methods for Assessing Economic Impacts of Labour Immigration

Many methodologies have been proposed to capture economic effects of immigration. There are two broad categories of available researches: econometric analyses and system-based simulation analysis. Econometric analyses estimate the effects of immigration and produce more data-driven results (Okkerse, 2008). On the contrary, results from system-based simulation analyses are more or less theory-driven and sensitive to changes in the underlying theoretical framework.

3.5.1 Econometric Approaches

Econometric analyses estimate the effects of immigration based on correlations that occur between variations in wages or (un)employment rates and variations in migration stocks or flows (Okkerse, 2008). There are four methods in econometric analyses, namely, area analysis, production theory approach, aggregate time-series analysis and natural experiments. The former two methods exploit the geographical diversity in migration concentrations; the third exploits changes in migration patterns over times; and the last one analyses impacts that occur after large inflows of migrants caused by political factors.

3.5.1.1 Area Analysis

Area analysis is frequently used to search for labour market effects of migration. Migrant populations concentrate in specific geographic areas and area analysis exploits this geographical diversity to look for effects of migration on regional labour markets. If areas with more immigrants have lower wages or higher unemployment rates, that finding would be consistent with the hypothesis that immigrants have a

depressing effect on local native labour market conditions (Okkerse, 2008).

The weakness of area approach is that most empirical studies do not build from a theoretical framework. Studies that use aggregated area cross-section data estimate a regression model of the form:

$$Y_i = \alpha + \beta X_i + \gamma P_i + u_i$$

Y_i is a measure of labour market performance of some native group in area i : for instance average wages, participation rates or unemployment rates. X_i is a vector of regional explanatory variables such as population size, population density, average education and so on. The key explanatory variable is the proportion of migrants in the regional labour force P_i . However, the model omits some relevant regional variables which might fail to have independent disturbances.

This approach examines the empirical relationship between the relative size of an immigrant group and the labour market performance of native workers without an explicit model of the labour market (Okkerse, 2008). There are two problems for area analysis to deal with. The first is a possible endogenous problem when migrants choose their destination area depending on the local wage or unemployment level. One technique to solve the endogenous problem is instrumental variables (IV) estimation (Pischke and Velling, 1997). Unfortunately, it is hard to find one or more instruments that are highly correlated with the concentration of immigrants but uncorrelated with the wage or unemployment levels. The second problem of area analysis is that natives may respond to the entry of immigrants in a local labour market by moving their labour or capital to other areas (Borjas, 1999a). To avoid the problem of outflows, some researchers change the analysis from the area to the industry, occupation, education or experience group (De New and Zimmermann, 1994; Card, 2001; Borjas, 2003).

Using this approach, most studies concentrate on the US and use US Census data, but

research for European countries is rare especially focused on Germany and Austria. De New and Zimmermann (1994) find that wage effects of -3.3% and even -6.4% for a 1% increase in immigrant share in Germany. According to Card (2001) a 1 percentage point increase in the immigrant share would decrease the native employment to population ratio by at most 1 percentage point.

3.5.1.2 Production Function

By estimating the parameters of different labour and non-labour inputs in production function, it provides important information about the degree of substitutability or complementarity between the various production factors. Following this approach, a variety of studies have examined the substitution possibilities among labour inputs defined by skill level, age, sex or educational attainment (Hamermesh, 1986). Diewert (1971) assumed a generalized Leontief production function with n production factors:

$$Q = \sum_i \sum_j \gamma_{ij} (X_i X_j)^{1/2} \quad (i, j = 1, \dots, n)$$

Where Q is output, X_i is input used of factor i , and γ_{ij} is the technology coefficients. The technology coefficient between a pair of inputs is negative if the inputs are substitutes and positive if the inputs are complements. The equation is linear in parameters and can easily be estimated with least squares techniques given data on wages and the relative proportions of the various inputs.

The advantage of production function is the estimated parameters show the degree of substitutability or complementarity between production factors. In addition, the elasticities of complementarity decided by parameters can provide a clear picture of wage changes occurring among native labours after shift in a supply of immigrant labour. The limitation of this approach is the disaggregation of the labour force into subsamples that many immigrant groups are treated as a single labour input.

Existing empirical research following the production function approach is almost

entirely based on the US data. On the one hand, Borjas (1986) suggested that immigrants and native male labours are complements. On the other hand, Borjas (1987) and Kohli (1999) found small negative effects of immigrants on the earnings of natives although the values of this competition are negligible. Borjas (1987) finds that a 1% increase in the number of white immigrants reduces the earnings of white immigrants by 1%.

3.5.1.3 Aggregate Time-Series Analysis

Time-series analysis is used to find out the link between immigration and unemployment. There are two different approaches in previous studies: non-structural estimation techniques, and conventional structural models. These two approaches reflect the debate on whether analysis should take a theory-driven or data-driven approach (Leamer, 1985).

The non-structural estimation techniques take a data-driven approach to examine whether there is a causal linkage between immigration and unemployment and in which direction causality runs. These techniques do not use a structural representation of the labour market but use causality testing procedures and minimize restrictions imposed on the data (Leamer, 1985). Using Granger causality tests to examine the relationship between Australian immigration and unemployment rates between 1948 and 1982, Withers and Pope (1985) did not find evidence of immigrants affecting the unemployment rate. Similarly, Shan *et al.* (1999) used a vector auto-regression model for Australia and New Zealand and found no such causality from immigration to unemployment.

The structural approach enables the theoretically specified linkages between immigration and unemployment to be empirically estimated. This approach models conventional labour market aggregates simultaneously with immigration flows. Labour market theory is used to specify the relevant form and content of the equations

to be estimated (Okkerse, 2008). Applying this technique on different theoretical frameworks, Pope and Withers (1993) reach the same results as from the statistical causality technique that there is no evidence of any association from migration to unemployment.

The advantage of time-series analysis is that it allows under certain conditions of cointegration both estimation of the long-run relationship between variables and identification of short-run structural parameters (Okkerse, 2008). Both approaches, data-driven or theory-driven, have to be seen as complementary in a sense that ‘facts’ could be determined by non-structural tests as a preliminary to subsequent structural estimation (Withers and Pope, 1985).

3.5.1.4 Natural Experiment

In the past, huge wave of immigration happens in a limited period of time caused by some political events. It is obviously that the causality of these migration flows is determined by political factors rather than host economic prosperity. A number of studies examining this "natural experiments" in immigration are able to shed light on the importance of biases in cross-section analysis (Friedberg and Hunt, 1995).

One example of such a natural experiment is the ‘Mariel boatlift’ that 125,000 mostly less-skilled Cubans migrated to Miami in a few months in 1980. The timing of this influx was politically determined, and the arrival location was due to Miami’s proximity to Cuba. This labour influx increased the labour force in Miami by 7%. Card (1990) examines the impact of the Cuban immigration on Miami labour market focusing on wages and unemployment rates of less-skilled workers. His data analysis and the comparison between predicted and actual wages show almost no effect on the wage rates and employment opportunities of non-Cuban workers. Even surprisingly, the Mariel immigration had no strong effect on the wages of other Cubans.

A more recent natural experiment is that of mass migration of Russians to Israel in the early 1990s. A politically unstable Soviet Union abolished emigration controls and the majority of the Jewish community chose to leave. They emigrated to Israel because there were neither entry restrictions nor waiting periods. At the peak of the immigration influx in 1990 and 1991 Russian immigrants increased Israel's working-age population by 8%.

Friedberg (2001) exploits the variation in immigration across occupations to study the impact of this mass migration on the Israeli labour market. Least-squares estimates on the earnings of native Israelis show that natives in occupations that receive more immigrants experienced lower earnings growth over the period 1989–1994. However, when previous occupations are used to instrument for current occupations, instrumental variable results suggest that immigrants enter occupations with low wages, low wage growth and contracting employment, rather than that they have an adverse impact on native labour market outcomes.

All these natural experiments deal with enormous migration flows in limited periods of time compared with normal migration movements. Nevertheless, these migration flows do not prove to be damaging for native labour market outcomes. Host economies can often absorb migrants in a small period of time. In other words, the natural experiment literature adds to the evidence suggesting a limited impact of immigrants on natives.

3.5.2 System-Based Simulation Approaches

Simulation-based analyses use the existing economic models to simulate the impacts of immigration. There are two different approaches to be distinguished in this section: the factor proportions approach that is a partial equilibrium approach and the

computable general equilibrium (CGE) approach.

3.5.2.1 Factor Proportions Approach

The factor proportions approach consists of three steps (Borjas *et al.*, 1992). First, it estimates the amount and educational composition of immigrated labour. Second, it calculates the percentage growth in the ratio of highly educated to less-educated labour attributable to this inflow. Finally, it assesses the potential effect of changes in these skill endowments on earning differentials by education. To summarize: ‘the factor proportions approach compares a nation’s actual supplies of workers in particular skill groups to those it would have had in the absence of immigration and then uses outside information on the elasticity of substitution among skill groups to compute the relative wage consequences of the supply shock’ (Borjas, 1999a).

Borjas (1999a) assumed a linear homogeneous Constant Elasticity of Substitution (CES) production function with two types of labour inputs, namely, skilled (L_s) and unskilled (L_u):

$$Q_t = A_t[\alpha L_s^\rho + (1 - \alpha)L_u^\rho]^{1/\rho}$$

Where Q_t is the output at time t , ρ is the parameter of substitution which can be calculated by the elasticity of substitution σ , $\sigma=1/(1-\rho)$. Following this approach, Borjas *et al.* (1992) estimated that immigration is responsible for about 44% of the widening wage gap between high school dropouts and high school graduates.

Jaeger (1995) uses a comparable approach but combines three labour groups in a nested CES production function. His results for the 1980s are consistent with those of Borjas *et al.* (1992). Immigration explains about 2.9 percentage points of the 13.4 percentage–point increase in the native dropout–college differential, but only 1.6 percentage points of a 12 percentage point increase in the native high school–college premium. Jaeger (1995) reports results not only on the relative wages but also on the level of wages. Immigration during the 1980s accounted for roughly one-third of the

decline in real wages for high school dropouts. The effects on the wage levels of other skill groups were comparatively smaller.

Borjas (2003) increases the number of labour aggregates using a three-level CES technology. The bottom level combines similarly educated workers with different levels of work experience into labour supply for each education group. The second stage aggregates workers across education groups into the national workforce. Finally, the upper level combines labour with capital. He uses data for four education groups and eight experience levels in 1960, 1970, 1980, 1990 and 2000 to estimate elasticities of substitution for each stage of the CES technology. With these estimates, Borjas (2003) calculates the wage impact of the immigrant influx that entered the USA between 1980 and 2000. Results show a wage decrease for the average native worker by 3.2%. Workers at the bottom and top of the education distribution are most affected with wage decreases of 8.9% and 4.9%, respectively.

The factor proportions approach has been criticized for relying too heavily on theoretical models (Okkerse, 2008). It does not estimate the impact of immigration on the wage structure; rather it simulates the impact for given elasticities of substitution. If the calculations or the estimate of the relative wage elasticity is false in the model of the labour market, the estimated impact of immigration is also false. Nevertheless, much evidence shows that relative supplies do affect relative wages and the factor proportions approach is a valuable instrument to gain insights in the wage effects of migration.

3.5.2.2 Computable General Equilibrium Approach

A computable general equilibrium (CGE) model describes an economy in equilibrium with endogenously determined relative prices and quantities (Bergman, 1990). The CGE model uses a set of equations to interpret the structure of an economy and describe the behaviour of all economic agents and the equilibrium conditions of all

markets. A calibration or estimation procedure fixes the parameters for the model's equations (Mansur and Whalley, 1984). After calibration, the model can be solved for an alternative equilibrium associated with any changes in policies. A comparison between the alternative and the benchmark equilibrium makes it possible to assess effects on allocation and on income distribution.

CGE models are not new to economic analyses, such as Dervis *et al.* (1982) firstly applied this technique in development economics and Shoven and Whalley (1984) in trade economics and public finance. This technique is also suitable for studying the impacts of migration. A CGE model can consider migration flows and simulate the responses of economic variables to these flows. Economic historians were the first use of this technique to problems of large-scale migration issues. For example, Williamson (1990) made a CGE model to study labour market effects of Irish immigration in Great Britain between 1821 and 1861.

It is important to find out the overall effects of immigration on receiving country before making a suitable immigration policy. This requires ultimately the integration of all these effects into an economy-wide model. Economy-wide models contains both macro- and micro- economic outcomes, for which the former focuses primarily on macroeconomic outcomes, such as GDP, employment, investment, and consumption, and the latter provides at the level of sectors of the economy, goods and services traded, and types of workers (Poot and Cochrane, 2005). It seems that Computable General Equilibrium (CGE) model is the most popular method for many economists to do the research.

Both macro and micro general equilibrium models are based on neoclassical economics and established from micro-foundation, i.e. the behaviour of rational individual consumers and firms. Both types of models follow the price mechanism, which makes the balance in the allocation of resources such that demand and supply

equilibrium. For considering the implications of varying levels of immigration on the economy, and the sensitivity of such economic outcomes to immigration policy, the CGE model is a natural tool as micro-level factors such as the demographic and skill composition of immigrants can be taken into account (Poot and Cochrane, 2005). Macro-level analysis is also important for CGE models. CGE models mainly calculate the market-driven allocation of a given total quantity of resources (labour, capital and natural resources) in the economy and they require an input of information (factors exogenous to the model) on certain macro-level variables, such as the total available capital stock and total labour supply (these exogenous factors that are fed into the model are called the 'model closure').

Weyerbrock (1995) makes use of a CGE model to study the effects of immigration into the EU. She concludes that labour migration into the EU does not cause the dramatic consequences that EU citizens often fear. She explains that negative effects, like increasing unemployment or decreasing wages and income per capita, are small even with huge migration flows. Adjustment problems for the labour market are smaller when immigrants also increase the capital stock. With limited migration an increase in income per capita is even possible, especially when labour markets are flexible. The more flexibly wages can react, the smaller possible negative effects will be. Therefore, Weyerbrock argues to make labour markets more flexible in the EU.

Muller (1997) studied the effects of migration on Switzerland within a simple CGE model and tested the sensitivity of the results for different modelling hypotheses on labour market segmentation, capital mobility and terms of trade. The results show that in general immigration has a positive but small effect on native welfare. Barrett *et al.* (2005) tried to simulate the impact of immigrants who arrived in Ireland during the economic growth of the 'Celtic Tiger' era (1993–2003). Although the immigrants have notably higher levels of education relative to the domestic populations, they are not all employed in occupations that fully reflect their educational levels. Results show that

immigrants increased GNP by 3% but worsened the position of the low skilled labour who face lower wages or higher unemployment rates. The impact of immigrants would be more favourable if there was no occupational gap and immigrants would have access to the same occupations as natives. GNP would then increase by more than 3% and earnings inequality would reduce.

Boeri and Brucker (2005) reach similar conclusions in an analysis on cost and benefits of East–West migration in the enlarged EU. They simulate the outcomes of expected migration flows under different assumptions about migrant skills, wage flexibility and levels of welfare benefits. When labour markets are clear, gains are large: immigration of 1% of the population increases GDP of the total EU region by around 0.3%. However, simulations with wage rigidities discover a policy dilemma: the total EU region can substantially gain from migration but only at the expense of the native population in receiving countries. This creates an incentive for a closing-the-door policy and the gains from migration would fail to develop.

The results by Boeri and Brucker (2005) are quite similar with findings from more complex simulation models on the impact of Eastern enlargement. The studies of Keuschnigg and Kohler (2002), Heijdra *et al.* (2002) and Brucker and Kohlhaas (2004) yield very similar results for Austria and Germany on the impact of immigration following enlargement. In all these models wages will decline by roughly 0.5% after immigration of 1% of the labour force and GDP in the host country will increase.

Another advantage of CGE models is that they can distinguish between different households. Negative effects can be strong for certain types of households but negligible for other types of households. Households that supply labour services comparable to labour services supplied by foreign workers are most hit by foreign competition. It often concerns less-skilled or former migrant households that are already at the bottom end of the income scale. In these cases it may be crucial that

minimum wages are kept or introduced for less-skilled workers to prevent increasing income inequality. A CGE assessment of the impact of illegal immigration on the Greek economy illustrates this point. Sarris and Zografakis (1999) showed that illegal immigrants decrease real disposable income of households headed by an unskilled person but benefit all other households.

To sum up, the CGE models are very useful to look for comprehensive economic impacts of international migration. Compared with most of the empirical methods discussed before, CGE models allow other variables to change as well. The variables include not only the labour market but also other factor markets, goods markets and external trade markets. Interactions that take place between these different markets are taken into account. CGE models not only study the effects of immigration on wages and employment but also consider the effects on household and per capita income and on macroeconomic indicators such as real GDP, the real exchange rate and total real exports and imports. Therefore, CGE approach is the best option that could fulfil the objectives of this study. The Chapter four will present the basic theories and mechanism of CGE model in detail, and the Chapter five will construct a specified CGE model for analysing the impacts of international immigration on the UK economy.

3.6 Summary

This chapter provides information of theories of international migration at first. The economic factors are the major causes of international migration, such as wage differentials, employment conditions, and income maximization. Given the significance of international migration for the receiving countries, the main part of this chapter reviews the economic impacts of international migration from five economic dimensions, namely, economic growth, labour market, domestic household,

international trade, tax revenue and public expenditure.

The empirical studies found that skilled international migration has unambiguously positive effects on economic growth of receiving countries, while the effects of unskilled migration depend on the elasticity of substitution of skilled and unskilled in both the high tech and the traditional sector. In the labour market, immigrants will lower the wage of domestic labours with which they are perfect substitutes, and further decline the employment rate of natives. However, there are two different points of the effects of immigration on domestic household welfare. Some economists support that immigration has had a significant adverse impact on the least skilled native workers, but some argue that immigration would have positive effects by increasing the average wages of native workers. The previous studies claim that international free trade and free migration are complementary rather than substitute. In addition, immigration has positive effects on trade that it has larger effect on import than export. The fiscal consequences of international migration have both positive and negative effects depend on the skill level of immigrants and the length of their stay.

The international migration also has other social impacts on both sending and receiving countries that international immigration has positive effect on improving the quality of population, encouraging the economic development of receiving countries, saving education and training costs, balancing the aging problem in developed countries, making contribution to the urban development, promoting cultural exchange and transmission, and increasing home countries' foreign exchange and investment capacity. However, the negative effects include a constraint for sustainable growth and the brain drain for sending countries, the problems of refugees, illegal immigration and transnational crime for receiving countries.

It is important to find out the overall effects of international migration on receiving country before making a suitable immigration policy. Comparing with other analytical

methods, the CGE model seems to be the most suitable to do the research for this study, as it is able to look for comprehensive economic impacts of international immigration.

Chapter Four:

CGE Model: Basic Theories and Mechanism

The Computable general equilibrium (CGE) model is taken from the neoclassical modelling tradition which was originally presented in a World Bank study by Dervis *et al.* (1982). This chapter is going to provide a description of CGE model at first, and then the mechanism of CGE model will be explained in detail. The method of data collection will be described in the following section. Finally, the evaluation of the application of CGE model is going to discuss and the history of applications of CGE model in UK policy research will be presented

4.1 General Definition of CGE Model

Quantitative simulations play a key role to evaluate alternative policy measures in applied economic research. Compared to analytical models, the numerical approach facilitates the analysis of complex economic interactions and the impact assessment of structural policy changes (Bohringer *et al.*, 2003). Among numerical methods, computable general equilibrium (CGE) models are widely employed by various national and international organisations (EU Commission, IMF, World Bank, OECD, etc.) for economic policy analysis at the sector-level as well as the economy-wide level.

Lofgren (2000) explains the meaning of the term CGE as follows: The term 'Computable' refers to the fact that the model solution can be computed, which is a prerequisite when a model is used for applied purposes, i.e. real data is used and solved on a computer. It is 'General' in the sense that the model represents the

behaviour of not just one type of economic agent, but all types of agents in the economy. By 'Equilibrium' it is implied that an exogenous change (from a policy shock or some other source) that affects any one part of the economy can produce repercussions throughout the system, i.e. the solution of the model is the set of prices and quantities that no agent has an incentive to change.

The CGE models are based on general equilibrium theory, which are a class of economic models that use actual economic data to estimate how an economy might react to changes in policy, technology or other external factors (Lofgren *et al.*, 2002). The general equilibrium is achieved when demand equals supply in all markets at prevailing prices, and assuming constant return to scale, zero profit conditions are satisfied for each industry (Shoven and Whalley, 1992). The main virtue of the CGE models is its micro-consistent representation of price-dependent market interactions. The simultaneous explanation of the origin and spending of the agents' income makes it possible to address both economy-wide efficiency as well as distributional impacts of policy interference. This has made CGE models a standard tool for the quantitative analysis of policy interference in many domains including fiscal policy, trade policy, and environmental policy (Bohringer *et al.*, 2003).

An alternative name for CGE models is applied general equilibrium (AGE) models. Dixon & Parmenter emphasized (1996) that CGE models use data for actual countries or regions and produce numerical results relating to specific real-world situations. They defined three distinguishing characteristics of CGE models:

- 1) They include explicit specifications of the behaviour of several economic actors, so they are general. Typically they represent households as utility maximizers and firms as profit maximizers or cost minimizers. They may also include optimizing specifications to describe the behaviour of governments, trade unions, capital creators, importers and exporters.

- 2) They describe how demand and supply decisions made by different economic actors determine the prices of at least some commodities and factors. For each commodity and factor they include equations ensuring that prices adjust so that demands added across all actors do not exceed total supplies. That is, they employ market equilibrium assumptions.
- 3) They produce numerical results, because they are computable. The central core of the database of a CGE model is usually a set of input-output accounts showing for a given year the flows of commodities and factors between industries, households, governments, importers and exporters.

4.2 Mechanism of CGE Model: How it Works

It is broadly acknowledged that CGE models are economy-wide models which describe a simultaneous general equilibrium in all markets of the economy. CGE models are widely applied to policy analysis in both developing and developed countries. This section mainly reviews the constructive process of CGE model and the relationships among main economic compositions in the CGE model, such as different production sectors, domestic institutions, consumption and trade.

4.2.1 Procedure of CGE Modelling

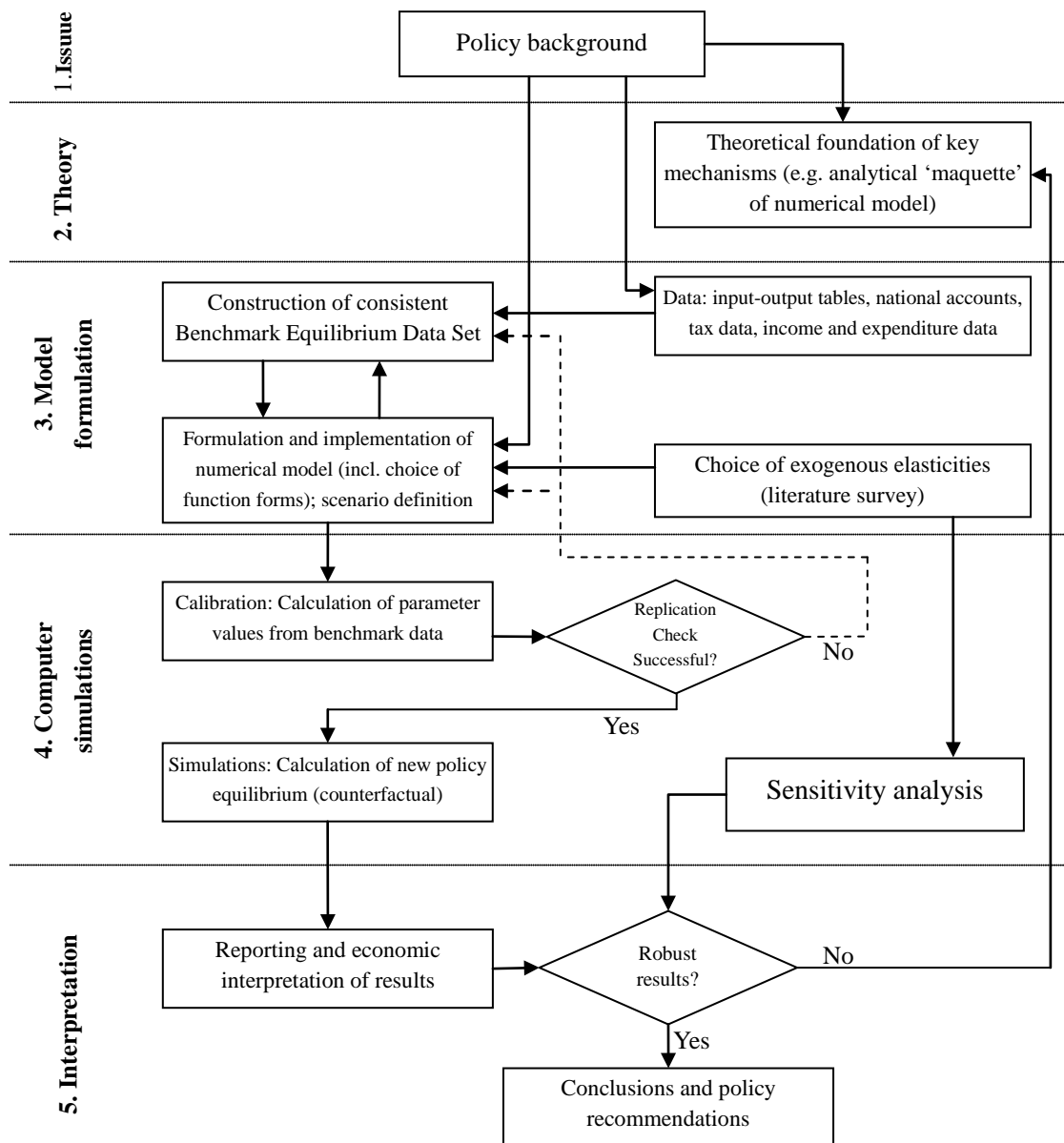
Bohringer *et al.* (2003) summarizes the five main steps involved in constructing and using CGE models, as showed in Figure 4.1 below. Initially, the policy issue must be carefully studied to decide on the appropriate model design as well as the required data. The second step involves the use of economic theory in order to lay out key economic mechanisms that drive the results in the more complex numerical model. The third

step needs to collect relative data to build up a consistent benchmark equilibrium database. The appropriate equations which are used to define the interrelationships of the macro economy are chosen for the CGE model formulation, and then implementation deliver the framework for numerical policy analysis. This step also involves the set-up of alternative policy instruments and strategies that includes scenario definition.

In determining results of policy simulation, it is important to make decisions on the choice and parameterization of functional forms. The benchmark database provides actual values for the parameters in the equations through a process known as ‘calibration’ (Mansur and Whalley, 1984). Calibration of the free parameters of functional forms requires a consistent one year’s data together with exogenous elasticities that are usually taken from literature surveys. The calibration is a deterministic procedure and does not allow for a statistical test of the model specification. The one consistency check that must necessarily hold before one can proceed with policy analysis is the replication of the initial benchmark: the calibrated model must be capable of generating the base-year (benchmark) equilibrium as a model solution without computational work (Bohringer et al., 2003). The following chapter will describe a detailed structure of CGE model for this study.

In the fourth step, it is possible to ‘shock’ the model with a change in a value of one of parameters or exogenous variables. The model is re-solved for a new (counterfactual) equilibrium, and then the changes in the values of the endogenous variables are compared to those of the benchmark equilibrium to provide information on the policy-induced changes of economic variables such as employment, production, consumption, relative prices, etc. Finally, the model results must be interpreted based on sound economic theory. Due to the reliance on exogenous elasticity values and a single base-year observation, comprehensive sensitivity analysis on key elasticities should be performed before concrete policy recommendations are derived.

Figure 4.1 Steps in computable general equilibrium analysis



Source: Bohringer *et al.*, 2003

4.2.2 Structure of CGE Model

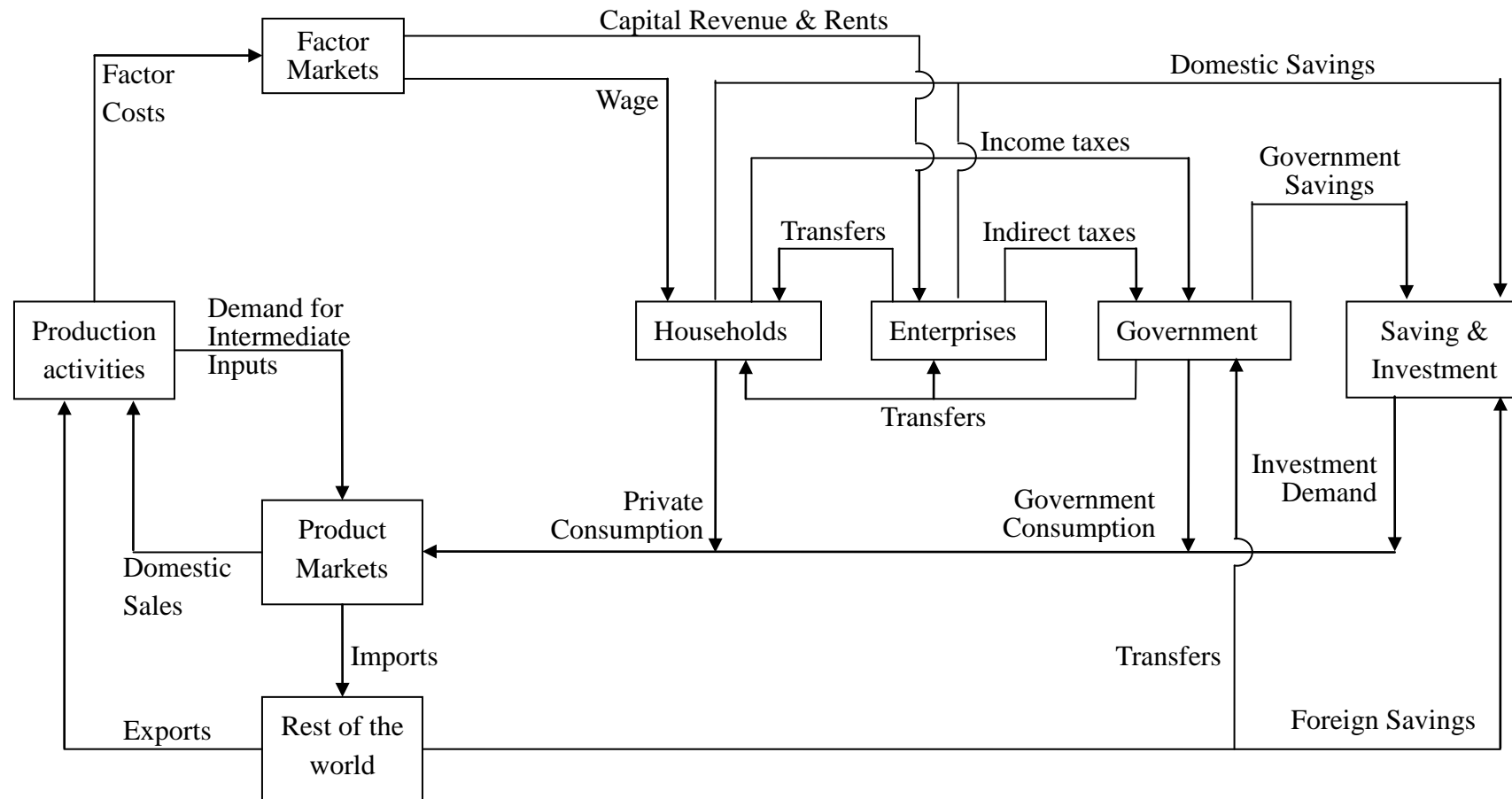
Lofgren *et al.* (2001) drew a bird's-eye perspective on the CGE model, which is

adjusted by author and shown in Figure 4.2. The Figure 4.2 highlights the links between CGE main compositions: producers, factor markets, commodity markets, households, the government, and the rest of the world. The arrows in the Figure 4.2 represent payment flows, which not only shows the initial distribution and redistribution of income, but also shows different interactional relationships among all economic agents. Different from the payment flow, real goods or services flow go in the opposite direction. In the UK model, all blocks except enterprises and the government will be further disaggregated and described in detail in Chapter Six.

From the left of the structure of the model in Figure 4.2, the production activities earn their income from sales in domestic and foreign markets. The income is allocated to purchases of intermediate inputs from products market and payments to production factors (i.e. capital, land and different types of labour). The producers maximize profits subject to production functions with neoclassical substitutability for factors and fixed coefficients for intermediate inputs, which is top of technology nest in the model. They are assumed to act in a perfectly competitive setting, taking the prices of outputs, intermediate inputs, and factors as given. The allocation of outputs between domestic market and exports is determined by the constant elasticity of transformation (CET) function.

For the domestic product markets, the demand side consists of investment demand, private consumption, government consumption, and intermediate input demands. The supplies come from domestic producers and the rest of the world (imports). In each market, the ratio between demands for products from these two sources depends on Armington elasticity, which is the elasticity of substitution between domestic and import products.

Figure 4.2 Major payment flows in the CGE models



Source: Lofgren *et al.* (2001), adjusted by author.

In the factor markets, the production activities pay factor costs to factors (land, capital and labour). In each market segment, a flexible price assures that quantities demanded and supplied are equal. In an imperfect labour market, labour supply equal to labour demand plus unemployed labour. The incomes of the factors are distributed to households and enterprises, which reflect the shares they control for each factor. Unless otherwise noted, the land and capital markets are segmented by activity, i.e., land and capital cannot move from one activity to another. On the other hand, each labour factor is able to move freely across all relevant activities.

The households may receive transfer payments from the government and enterprises. The households allocate this income to pay income taxes to the government, saving and product consumption. The enterprises may also receive transfer payments from the government. The expenditures for enterprises include taxes, saving and transfer to households, but no consumption on product markets.

The government income is mainly collected from taxes and transfers from the rest of the world. These are used for consumption of fixed commodity quantities, transfers to households and enterprises, and savings. Alternative treatments are possible with regard to the determination of government savings. They may, for example, be a flexible residual, defined as the difference between government revenues and expenditures. Another alternative is to fix government savings while permitting a tax instrument to vary to assure that this fixed savings level is realized (Lofgren *et al*, 2001).

In the savings-investment block, savings from the domestic institutions and the rest of the world are utilized to the total purchase of investment goods, such as government capital formation, private capital formation, and stock changes. The country gets foreign payment from exports to the rest of the world and from transfers to the government. On the other hand, these foreign incomes are used to purchase import goods.

4.3 SAM Database in CGE Model

Data collection is an important part in the procedure of CGE model. Basically, data in a form of an Input-Output table or Social Accounting Matrix (SAM) make the core for CGE model. Following the research of NOBEL prize-winner Richard Stone, the SAM is a comprehensive, disaggregated, consistent and complete data system that captures the interdependencies that exist within a socio-economic system (Mabugu, 2005). The versatility of SAM has made it popular for economic modelling. Techniques of SAM estimation are developed in the works of Robinson and El-Said (1997), Robinson, Cattaneo, and El-Said (2000), etc.

The data sources for a SAM come from Input-Output tables, national income statistics, and household income and expenditure statistics (Sen, 1996). An Input-Output table records economic transactions alone irrespective of the social background of the transactors. Therefore, compared with Input-Output (I-O) model, SAM has two advantages.

First, in most I-O models, income distribution is shown by way of value (generated by sector) divided into its different components, such as wage and non-wage incomes. This functional distribution of incomes is not helpful when one has to evaluate the effects of policy changes on real incomes at the household level. Therefore, the SAM framework complements this limitation by adding an additional account in which the functional distribution of incomes (over labour and capital) was mapped on to a more disaggregated distribution of incomes across institutions (including households, firms and government).

Second, in the I-O model, final expenditures are assumed to be exogenous. This meant that the I-O model could only estimate the impact of an exogenous change in final demand on production and income; it ignored any feedback effect of the induced income change on final demand and further, on production. The circular flow of income, thus, was not closed in the I-O model, as the model

lacked any interrelationship between value added and final demand. However, the SAM corrects this major deficiency of the I-O system (Pradhan *et al.*, 2006, p70).

Technically, SAM is an organised matrix representation of all transactions and transfers, actual or imputed, that take place in a given accounting period, between different production activities, factors of production (labour and capital), and institutions (like households, firms and government), within the economy and with respect to the rest of the world (Pradhan *et al.*, 2006). SAM is a data system, including both social and economic data for an economy. A SAM is thus a comprehensive accounting framework within which the full circular flow of income, from production to factor income to household incomes to household demand and back to production, is captured. In a SAM, all the transactions in an economy are presented in the form of a matrix that each row of the SAM details the receipts of an account while the columns detail the corresponding expenditure (Lofgren, 2002).

In general, there are six sets/types of accounts being distinguished in the SAM (McDonald and Punt, 2001), including:

1. activity (or production) accounts,
2. commodity accounts,
3. factor accounts,
4. institutional accounts (households, enterprises and government),
5. savings-investment accounts, and
6. rest of the world (ROW) accounts.

Table 4.1 shows the basic structure of a SAM used in the CGE model. Each cell in the SAM is represented by a numerical estimate of the value of the transactions that correspond to it. It clearly shows that each account is represented by a row and a column in which the payment from the account of its column to the account of its row. Therefore, the incomes of an account appear along its row and its expenditures along its

column, which row total (total revenue) equals column total (total expenditure).

Activity accounts record transactions by the productive activities. Therefore, the column 1 provides information regarding intermediate inputs, value added and producer taxes within the economic system; the row 1 shows the gross output of activity accounts (as shown in Table 4.1).

Commodity accounts record the demand and supply of commodities in the economy. The row 2 in Table 4.1 shows the distribution of commodities between intermediate demand and final demand. Final demand is made up of consumption demand by households and government. Investment and export demand from the rest of the world is also included, which represents the capital and exported commodity values. The commodities domestic consumed are valued at the same price, which is the so-called law of one price. An exception is the domestic price of exported commodities, which are valued at the world price of exports multiplied by the exchange rate as well one minus the export tax rate (Lofgren, 2002).

Factor accounts (including different types of labour, capital and land) represent income earned by and expenditure made by factors. Row 3 shows that income to factors occurs from the value-added payment by domestic production activities and payments for domestically owned factors used in the rest of the world. The income of labour factor is usually in the form of wages, while capital earns profits and land earns rent. Factor account expenditures, shown in column 3 of Table 4.1, are distributed between domestic and foreign-based owners of the factors.

Institutional accounts, including households, enterprises and government, provide information about the transactions between the production accounts and institutions, as well as among institutions. McDonald and Punt (2001) explained that institutional accounts are therefore where much of the richness of economic detail provided by the SAM is recorded. Row 4, 5 and 6 in Table 4.1 present the sources of income for

households, enterprises and government, separately; while column 4, 5 and 6 shows their expenditures. Households earn their income mainly from factors, but also from transfers from other institutions or the rest of the world. Household income is in turn distributed between consumption, transfers to other households, direct taxes, and savings. Enterprises earn income from non-distributed firm profits, as well as from transfers, whereas surplus income is distributed between taxes and transfers to other institutions and the rest of the world, as well as enterprise consumption and savings. Government receives income from various tax sources, from the ownership of factors, and from transfers from other institutions and the rest of the world. Expenditure is made up of transfers and government consumption demand (Lofgren, 2002).

Savings-Investment accounts refer directly to domestic investment and its funding. Income to savings-investment account comes from savings by institutions and the rest of the world, whereas expenditures record investment that is often limited to investment expenditure (as shown in Table 4.1).

The rest of the world accounts record the trade transactions, which are important if trade policy issues are to be analysed. Imports are an income to the ROW that are associated with expenditures by domestic agents, whereas exports represent expenditures by the rest of the world, and hence an income to the domestic accounts.

Table 4.1 The basic SAM structure used in the CGE model

Receipts	Expenditures								
	Activities	Commodities	Factors	Households	Enterprises	Government	Savings-Investment	Rest of the World (ROW)	Total
	1	2	3	4	5	6	7	8	9
1 Activities		Marketed outputs		Home-consumed outputs					Activity income (gross output)
2 Commodities	Intermediate inputs	Transaction costs		Private consumption		Government consumption	Investment	Exports	Demand
3 Factors	Value-added							Factor income from ROW	Factor income
4 Households			Factor income to households	Inter-household transfers	Surplus to households	Transfers to households		Transfers to households from ROW	Household income
5 Enterprises			Factor income to enterprises			Transfers to enterprises		Transfers to enterprises from ROW	Enterprise Income
6 Government	Producer taxes, value-added tax	Sales taxes, tariffs, export taxes	Factor income to government, factor taxes	Transfers to government, direct	Surplus to government, direct enterprise taxes			Transfers to Government from ROW	Government income
7 Saving-Investment				Household savings	Enterprise savings	Government savings		Foreign savings	Savings
8 Rest of the World (ROW)		Imports	Factor income to ROW		Surplus to ROW	Government transfers to ROW			Foreign exchange outflow
9 Total	Activity Input	Supply expenditures	Factor expenditures	Household expenditures	Enterprise expenditures	Government expenditures	Investment	Foreign exchange inflow	

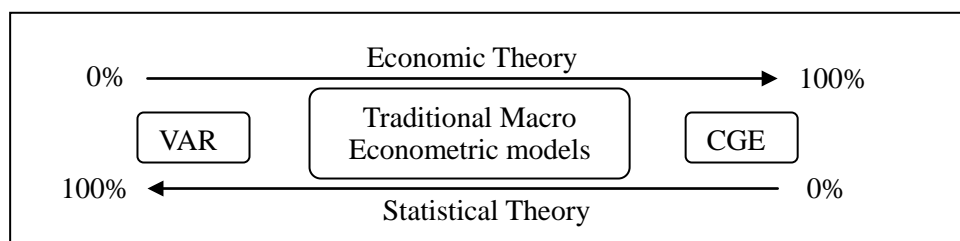
Source: Lofgren et al (2002)

4.4 Evaluation of CGE Models

There are various economic models for policy analysis, as discussed in section 3.6 before, and each model has its own strength and weakness. So does CGE model.

Firstly, CGE model is an economical theoretical model. It is worthwhile to consider the family tree of economic models. CGE-modelling starts with a theoretical model, and then finds data that fits the construct. CGE models have an economical theoretical depth, but they take a very liberal view on statistical methodology. On the contrary, the VAR (Vector Autoregressive) models have very high content of statistics, but almost no economic content. The traditional economic models are located somewhere in between, drawing both on classical statistical methods, as well as some economic theory (Petersen, 1997). The Figure 4.3 illustrates this generalisation below.

Figure 4.3 The family tree of economic models



Source: (Petersen, 1997)

CGE models have a solid basis of micro-economic theory. A typical CGE model generally strongly associated with the standard neoclassical micro-economic theory, which brings various economic entities into a system framework. This is the most powerful feature for CGE model (Borges, 1998). This advantage of CGE model makes it easier for builders to judge the reasonability of model results according to the corresponding theories, which is the one of differences between CGE models and macro-econometric models. Macro-econometric models often lack such rigorous

theories and cannot provide useful simulation of the economic effect when economy run out of its trend line. In addition, CGE models mostly use one-year base period data to obtain the relevant parameters by using 'calibration' method, while the parameters of econometric models are based on time-series data.

Secondly, CGE models are compatible with the advantages of input-output and linear programming models. At the meantime, it overcomes the disadvantages of input-output models which ignoring the role of markets. The commodity market and factor market are organically linked through prices, which not only reflects the market mechanism, but also reflects the general linkages between different economic entities and different sectors in the economic system. Compared with input-output model, Zheng and Fan (1999) provided the detail advantages of CGE:

1. Firstly, through the introduction of economic agents' (such as enterprises, household, government, etc) optimization behaviour, CGE model describes the relationship of substitution between factors and the relationship of substitution and transformation between commodities demands.
2. Secondly, CGE model uses non-linear functions to replace the traditional input-output model's linear functions.
3. Thirdly, on the basis of input-output model, CGE model introduce a variety of economic agents and the price mechanism to combine supply, demand, trade and price together in order to find out the reaction of businesses and consumers to the relative prices caused by external economic changes. The main virtue of the CGE approach is its micro-consistent representation of price-dependent market interactions (Bohringer *et al.*, 2003).

Thirdly, CGE model coordinates the mechanism of economic system within the interaction of economic agents. In the chain of economic networks described by CGE

model, whether exogenous shocks or policy changes, as long as it is linked with the supply or demand of economic entities' decision-making, it will base on economic entities' optimal decision-making behaviour to transmit its impact to the entire economic system, which include both of direct and indirect effects. The simultaneous explanation of the origin and spending of the agents' income makes it possible to address both economy-wide efficiency and distributional impacts of policy interference. This is another characteristic of CGE model that other economic models cannot match. Therefore, the simulation results of CGE model are usually more detailed, more comprehensive and more reasonable than other models'. In detail, CGE model reflects the universal links between economic entities in reality, so not only can analyse the overall economic changes, but also can study the sector-level changes.

Fourthly, CGE models incorporate both short-run supply constraints and less than instantaneous adjustment responses in investment, land supply, population, and (commodity and factor) prices. Thus, CGE models can capture both positive gross multiplier and negative displacement effects from exogenous factors. Yet, likely due to convenience, CGE models have typically been patterned after those used in national and international studies (Partridge and Rickman, 1998).

In the framework of general equilibrium analysis, CGE models fully use the transaction information between sectors and economic agents to capture the complex linkages and interaction in the economic system. Therefore, the significance of using CGE models in studying economic issues is that it can be close to actual description of the relationships between economic agents in complicated economic system, so that the results can better explain the reasons for the phenomenon, as well as more accurately predict the trends of future economic development (Zhao and Wang, 2008). And, once the CGE model established, it provides a convenient tool to conduct various possible policy analyses.

The computational approach to policy analysis, however, also has shortcomings of its

own. Shoven and Whalley (1992) made some criticisms directly at the application of CGE models, as followed:

- 1) It is mainly criticized at the lack of parameter specification. The elasticities and other key parameters play an important role in CGE models. However, in most cases, there is no satisfied value for elasticities, and usually based on experience to set the value, which causes the criticisms of the credibility of the results.
- 2) The criticism is on making too many assumptions before building the model. No matter building a theoretic model or applied model, it is necessary to make some assumptions before constructing a general equilibrium model, such as full employment and perfect competition.
- 3) Unlike econometric studies, it is not possible to statistically validate the structure and underlying assumptions of the CGE model. As the SAM only reflects a ‘snapshot’ in time and does not contain detailed time series such as are used in econometric analyses, the direction of effects is more reliable than the magnitude.
- 4) As a consequence, CGE analyses are often perceived as a ‘black box’ to non-expert readers. All they can do is to “... deliver summary grunts of belief or disbelief but find it difficult to articulate reasons in a disciplined way” (McCloskey 1983).

4.5 The Application of CGE in Policy Research

Application of CGE models to development policy has started by the work of Dervis, de Melo, and Robinson (1982), which is a World Bank study. It is generally considered as

the basic, or standard general equilibrium approach for development policy in the world. Supporting the formulation of a general equilibrium model is firstly developed to conduct of economic policy in developing countries. A close look is given to a CGE for a closed economy, which is later extended to the issues of trade policy, income distribution, external shock, public finance, economic restructuring, and resource allocation element in both developing and developed countries (Zhao and Wang, 2008).

Sadoulet and de Janvry (1995) gave a complex view on macroeconomic modelling applied to development policy, starting with basic definition of elements, solving partial equilibrium problems, and ending up in a complex CGE model. Devarajan, *et al.* (1994) gave a very clear overview of macroeconomic modelling and CGE, and gave the general model a modern touch extending it by progressive functional forms, specified the relations between model elements and also provided methodology for model solution. A very recent work at the International Food Policy Research Institute (IFPRI) by Lofgren *et al.* (2002) gave a detailed presentation of a one-country based, static, standard CGE model. The work described in detail the system of equations, application and solution of the model by computer, and also discussed the required database. This paper is one of the main resources this study refers to. This study extends the presented standard model by multi-region formulation, by four-level nested CES production functions, and by developing labour market imperfect to the model, which will be presented in detail in the Chapter five.

The CGE models has been developed and applied broadly in different areas. Itakura (2004) made trade policy application on CGE to estimate the economic effects if Japan joins in the ASEAN. Thissen *et al.* (2001) used CGE model to research the devaluation problem in Egypt. Xie *et al.* (2000) and McKibbin *et al.* (2004) built up CGE models to analyse the impacts of reducing emission under the framework of Kyoto Protocol. There are also a number of researches, based on CGE models, on water issues (such as Azdan, 2001; Berrittella *et al.*, 2007; Feng *et al.*, 2005), income distribution and poverty (see

Agenor *et al.*, 2003; Savard, 2005), tourism (see Wattanakuljarus, 2006), traffic (see Munk, 2003; Steininger *et al.*, 2007), and education (see Jung *et al.*, 2003), etc.

Table 4.2 Recent Policy Researches on the UK by CGE Model

Authors	Date	Content
Espinosa, J.A. & Smith, V.K.	1995	Presents a nonmarket CGE model measuring the environmental consequences of trade policy.
McDonald, S. & Roberts, D.	1998	The economy-wide effects of the BSE crisis
Greenaway, D.; Reed, G.; Winchester, N.	2002	Trade and rising wage inequality in the UK
Blake, A.; Sinclair, M.T.; Sugiyarto, G.	2003	The effects of the foot and mouth disease on tourism, agriculture and all other sectors of the UK economy
Rutten, M.; Blake, A.; Reed, G.	2004	The economic impact of health care provision
Blake, A. <i>et al.</i>	2006	Current and forecast levels of tourism and its contribution to the economy
Baasa, T.; Bruckera, H.	2008	Macroeconomic impact of Eastern enlargement on Germany and UK
Turner, K.	2008	Investigate the conditions under which rebound effects may occur in the Scottish regional and UK national economies

Source: Author's collection.

There are lots of researches using CGE models in analysing policy simulation on the UK. As shown in the Table 4.2, CGE models have been used in a wide range of areas in UK economy as well. Espinosa and Smith (1995) used CGE model to measure the environmental impact of new GATT trade agreement on the UK; McDonald and Roberts (1998) used it to investigate the economy-wide effects of the Bovine Spongiform Encephalopathy (BSE) crisis, which was the most significant agricultural policy issue in the UK; Greenaway *et al* (2002) tried to use a CGE model to analyse the linkage of trade and wage inequality in the UK; Blake *et al* (2003) developed a CGE model to assess the economy-wide effects of the Foot and Mouth Disease in the UK, with particular attention to the tourism sector; Rutten *et al* (2006) used CGE model to focus on the macro-economic impacts of changes in the health provision via its effects on the

UK labour market.

CGE models are becoming more and more popular throughout the international migration researches. A CGE model provides the best framework to reassess the economy-wide and in-depth sectoral impacts of immigration (Poot and Cochrane, 2005). At a global level, Walmsley and Winters, (2003) used a CGE model to calculate the gains to the global economy from removing restrictions on international migration. There are some researches of the impacts of immigration on individual country based on CGE models in recent years. For example, Goto (1996) assessed the impact of migrant workers on the Japanese economy, Sarris and Zografakis (1999) studied the impact on wages of skilled and unskilled workers due to an inflow of illegal immigrants into Greece, Chang (2004) considered the wage differential between skilled and unskilled labour in Australia, and Baas and Brucker (2008) examined the macroeconomic consequences of EU enlargement on Germany and UK. The more detail of using CGE models to do the analysis of the economic impacts of immigration on the receiving country has been discussed in section 3.6.2.2 before.

However, the application of CGE model on UK immigration labour is quite few. Since the enlargement of EU, most economists did the research covering most main EU countries, and the UK is a part of them. In the UK, the CGE modelling approach was successfully adopted by Baas and Brucker (2008) to assess the impact of a range of immigration scenarios by means of the IFPRI model, which follows the neoclassic-structuralist modelling. The model was consisted of sixteen commodities (each commodity corresponds to an industry), sixteen domestic industries (two agricultural industries, four manufacturing industries and ten service industries), two types of households (native and migrant households), and two trading partners (the EU and the rest of the world). They also used a wage curve, which postulates a negative relationship between the real wage rate and the unemployment rate (Blanchflower and Oswald, 1995), to reflect specific labour market imperfections. As a result, they found wages in

the UK increase by 0.3%, employment growth of 1.3%, GDP increase by nearly 1%, exports to EU countries increase by 2.4% but to ROW countries by 1.2%, imports from EU countries increase by 3.6% and from ROW countries increase by 1.5%.

4.6 Summary

This chapter gives a comprehensive knowledge of CGE model. The first section provides the general definition of CGE and the characteristics of it. There are five steps in the procedure of CGE modelling, namely, policy issues, theoretical foundation, model formulation, computer simulation and interpretation. The structure of CGE model is composites of six main economic agents, which are producers, factor markets, commodity markets, households, the government, and the rest of the world. Furthermore, the CGE model not only shows the initial distribution and redistribution of income, but also shows different interactional relationships among all economic agents.

Data collection is an important part in the procedure of CGE model. The SAM is a comprehensive, disaggregated, consistent and complete data system that captures the interdependencies that exist within a socio-economic system (Mabugu, 2005). Therefore, it is popular to use SAM as the core database for CGE modelling. The advantages of CGE model show that it is a theory-based model, which brings various economic entities into a system framework. The simulation results of CGE model are more detailed, more comprehensive and more reasonable. As a result, the application of CGE has been broadly applied on the issues of trade policy, income distribution, external shock, public finance, economic restructuring, and resource allocation element in both developing and developed countries.

Chapter Five:

Construction of UK CGE-ILA Model

5.1 Introduction

The extended CGE model for UK immigration labour analysis (CGE-ILA) in this research is constructed for the benchmark year 2004. It consists of nine aggregated industrial sectors, nine aggregated composite goods, five production factors (including four different skill types of labour and capital), seven domestic institutions (including five different income levels of households, enterprises, and government), a saving-investment account, and a disaggregated rest of world account, based on the UK Social Accounting Matrix (SAM) and additional data presented in the Chapter seven.

The theoretical side of this model has been presented in the Chapter 5 above. For the technical structure and solution of the model, it closely follow the standard CGE model described in Lofgren *et al* (2002) which is used by the International Food Policy Research Institute (IFPRI). There are some major differences for UK CGE-ILA model from the standard CGE model.

1. The consideration of four types of labour allows considering the impacts of different types of skilled labour immigration on UK labour market and economy. Based on STAGE_LAB model, the study of McDonald and Thierfelder (2009), these different types of skilled labour are aggregated by a series of nested Constant Elasticity of Substitution (CES) production functions.
2. The division of five different income level households would be helpful to find out a deeper insight of the impacts of labour immigration on their welfares.

3. Furthermore, in order to learn the effects of European integration, the two country framework of the IFPRI model is enhanced to a three country framework which reflects one country (UK) and two regions, the rest of EU (ROE) and the rest of world without EU (ROW). The UK economy is linked to the EU and to the rest of the world via trade in goods and services, capital flows and the migration of labour. As a member of EU, the transaction costs between UK and EU are much lower, and directly encourage capital movements and labour migration.
4. Another important feature of the model is the relaxation of the assumption of full employment of labour. The structure of the model and the modelling of labour market imperfections are discussed in the following sections.

The model is a SAM based CGE model, wherein the SAM serves to identify the agents in the UK economy. The following section in this chapter is going to identify the behavioural relationships among UK agents these are defined by reference to the sub matrices of the SAM within which the associated transactions are recorded. Section 5.3 involves the identification of the components of the transactions recorded in the SAM, especially with those governing inter-institutional transactions. This section presents the price relationship, quantity relationships and production relationships in detail. Section 5.4 gives an algebraic statement of the CGE-ILA model in five groups. A full listing of the parameters and variables contained within the model are located in Appendix 1. Section 5.5 chooses the optional macroeconomic closure and section 5.6 collects the important elasticities for the model by reviewing the existing literature. The final section summarises the chapter.

5.2 Behavioural Relationships among Agents of UK Economy

Although the SAM accounts identify the model is consisted of the agents, and the SAM transaction records determine the activities of transaction, the model is defined by the behavioural relationship. Relationships among the activities of the model are a mixture of non-linear and linear relationships of how to manage the agents will respond to exogenous changes in the model parameters and/or variables. Table 5.1 summarises these relationships of activities by reference to the sub matrices of the SAM for the UK, which will be detailed in chapter six.

In social activities, the households consume a set of ‘composite’ commodities, which are aggregates of domestic production and imported goods. These ‘composite’ commodities are formed as Constant Elasticity of Substitution (CES) reflects the presumption on the aggregation of domestic and imported goods from both ROW and ROE are imperfect substitutes. The best ratios of imported and domestic commodities are determined by the relative prices of the imported and domestic commodities. This is the so-called Armington ‘insight’ (Armington, 1969), which allows for product differentiation via the assumption of imperfect substitution (Devarajan *et al.*, 1994). The assumption has the advantage of rendering the model practical by avoiding the extreme specialisation and price fluctuations associated with other trade assumptions (McDonald & Thierfelder, 2009). It is supposed that the UK in this model accepts all imported commodities’ prices.

Domestic production adopts the production process in two main stages. In the first stage total intermediate and total value added (primary inputs) are combined using either CES or Leontief technologies. At the top level total intermediate inputs are combined with total primary inputs to generate the outputs of activities; if a CES specification is chosen then the proportion of total intermediates and total primary inputs vary with the (composite) prices of the aggregates, while if a Leontief specification is chosen then

total intermediates and total primary inputs are in fixed proportions (McDonald & Thierfelder, 2009). In CGE-ILA model, the CES technology is chosen as the first level aggregation.

In the second stage, Leontief technology is used to generate demand for intermediate inputs which are in relatively fixed proportion of total intermediate inputs in each activity. In addition, the primary inputs in the second level are combined to form total value added by using CES technologies, with the optimal ratios of primary inputs being determined by relative factor prices. There is another three-level nested CES production functions used to aggregate different skill types of labour and capital in this study.

The activities refer to the assumption that the combination ration of industrial commodity outputs remains unchanged. Therefore, the demand for any given commodities has unique corresponding production of activity outputs. The Constant Elasticity of Transformation (CET) function is used to determine the optimal distribution of domestically produced commodities between the domestic and export markets. The detailed division of commodities and activities are presented in the following Chapter (Chapter Six: SAM for UK 2004).

The other behavioural relationships in the model are generally linear. There are some features worth mentioning as the following (McDonald & Thierfelder, 2009).

First, all the tax rates are declared as variables with various adjustments and/or scaling factors that are declared as variables or parameters according to how the user wishes to vary tax rates. If a fiscal policy constraint is imposed then one or more of the sets of tax rates can be allowed to vary proportionately and/or additively to define a new vector of tax rates that is consistent with the fiscal constraint.

Table 5.1 The Basic Behavioural Relationships for the CGE-ILA model

	Activities	Commodities	Factors	Households	Enterprises	Government	Savings- Investment	Rest of EU (ROE)	Rest of World (ROW)	Total
Activities		Domestic Production								CES production functions
Commodities	Intermediate inputs (CES)			Utility Functions, (CD or Stone- Geary)	Fixed in real terms	Fixed in real terms and export taxes	Investment	Exports ROE to	Exports to ROW	Commodity Demand
Factors	Factor Demands (CES)							Factor income from ROE	Factor income from ROW	Factor income
Households			Fixed shares of factor income	Fixed shares of income	Fixed shares of dividends	Fixed Transfers		Remittances	Remittances	Household income
Enterprises			Fixed shares of factor income			Fixed Transfers		Transfers	Transfers	Enterprise Income
Government	Indirect taxes	Sales taxes, tariffs, export taxes	Fixed shares of factor income, direct taxes on factor income	Direct taxes on Households income	Fixed shares of dividends, Direct taxes on Enterprise Income			Transfers	Transfers	Government income
Saving- Investment				Household savings	Enterprise savings	Government savings (residual)		Foreign savings from ROE	Foreign savings from ROW	Total Savings
Rest of EU (ROE)		Imports from ROE	Fixed shares of factor income							ROE Total 'Expenditure'
Rest of World (ROW)		Imports from ROW	Fixed shares of factor income							ROW Total 'Expenditure'
Total	Activity Input	Commodity Supply	Factor expenditures	Household expenditures	Enterprise expenditures	Government expenditures	Total Investment	Total 'Income' from ROE	Total 'Income' from ROW	

Source: Lofgren et al (2002), adjusted by author

Second, technology changes can be introduced through changes in the activity specific efficiency variables, adjustment and/or scaling factors are also available for the efficiency parameters.

Third, the proportions of current expenditure on commodities defined to constitute subsistence consumption can be varied.

Fourth, although a substantial proportion of the sub matrices relating to transfers, especially with the rest of the world, contain zero entries, the model allows changes in such transfers.

And fifth, the model is set up with a range of flexible macroeconomic closure rules and market clearing conditions. While the base model has a standard neoclassical model closure, e.g., full employment, savings driven investment and a floating exchange rate, these closure conditions can all be readily altered.

5.3 Transaction Relationships in the CGE-ILA Model

The transactions relationships among UK economic agents are laid out in Table 5.2. The prices of composite commodities for domestic consumption are defined as PQ_c , and they are the same for all institutions purchase. The quantities of domestically demanded commodities are divided into intermediate demand ($QINTA_a$) and final consumption (which is further subdivided among consumption by households QH_c , government, QG_c , investment, $QINV_c$, and stock changes, $qdst_c$). The value of total domestic demand, at purchaser prices, is therefore $PQ_c * QQ_c$. Consequently, the domestic commodities are exported to ROW (rest of world without EU) and ROE (rest of EU), and the export demands are set as QE_c and QEE_c , separately. However, the prices of exported

commodities are different with PQ_c , that $PE_c = pwe_c * EXR$ and $PEE_c = pwee_c * EXRE$, which do not follow the law of one price.

The prices of commodity supplies come from domestic activities are defined as $PXAC_c$, and the total domestic production of commodities being denoted as $QXAC_c$. Commodity imports from ROW (QM_c), are valued carriage insurance and freight (CIF) paid, PM_c , is defined as the world price except EU (pwm_c) times the exchange rate (EXR), plus an adjustment for import tariffs (tm_c). However, due to the EU trade policies, there are no tariffs for commodities imported from EU. Therefore, for goods from ROE (QME_c), PME_c is their prices, which is defined as $pwmec * EXRE$. Domestic consumption of all goods are subject to a variety of product tax, for example, sales taxes (tq_c).

Domestic production activities receive average prices for their output (PX_c) which are determined by the commodity composition of their outputs (McDonald & Thierfelder, 2009). As activities produce multiple outputs, the outputs can be represented as QX_c , formed from the commodity composition of outputs. In addition to intermediate inputs, activities also purchase primary inputs of factors ($QF_{f,a}$), for which they pay average prices (WF_f). In order to make the CGE-ILA model more flexible, the prices of each factor are different according to each activity. Finally each activity pays production taxes, the rates, ta_a , for which are rate of tax on producer gross output value.

Both domestic and overseas factors are allowed to be used in domestic activities, and domestic factors can be used abroad as well. Therefore, factor incomes (YF_f) accumulate from payments by both domestic and foreign activities. Payments by foreign activities are assumed exogenously determined and are denominated in foreign currencies. After the payment of factor taxes (tf_f), the remaining factor incomes are divided in fixed ratios among domestic institutions (households, enterprises and government) and the rest of world (ROW and ROE).

Household incomes (YI_h) mainly receive from factors, enterprises transfer ($TRII_{h,en}$), government transfer ($TRII_{h,gov}$) and transfers from the rest of the world (ROW and ROE), which are defined as the foreign currency multiplied by the exchange rate. In expenditure column, households pay direct income taxes ($TINS_h * YI_h$), deduct money saving ($MPS_h * YI_h$), and expend the residual income on commodities consumption, $PQ_c * QH_{c,h}$, which is determined by the household utility functions.

The account of enterprises receives income from factor sales, mainly in the form of profits from factors, government transfer ($TRII_{en,gov}$), and foreign currency denominated transfers from the rest of the world ($trnsfr_{en,row} * EXR + trnsfr_{en,roe} * EXRE$). Then, its spending is composed of the transfers to household ($TRII_{h,en}$), payment of direct income taxes ($TINS_{en} * YI_{en}$), and savings ($MPS_{en} * YI_{en}$). For government account, incomes (YG) accrue from the various tax implements, such as import and export duties (tm_c & te_c), sales, production and factor taxes (ta_a , tva_a , tq_c & tf_f), and direct taxes ($TINS_i$). The government also receives foreign currency denominated transfers from the rest of the world ($trnsfr_{g,row} * EXR + trnsfr_{g,roe} * EXRE$). In government expenditure column, government savings ($GSAV$) is defined as the difference between government income (YG) and government expenditure (EG). In the absence of a clearly definable set of behavioural relationships for the determination of government consumption expenditure, $PQ_c * QG_c$, the quantities of commodities consumed by the government are fixed in real terms, and hence government consumption expenditure will vary with commodity prices (McDonald & Thierfelder, 2009). Transfers by the government to other domestic institutions are considered as other domestic institutions' income.

Table 5.2 Transaction Relationships for the CGE-ILA model

	Activities	Commodities	Factors	Households	Enterprises	Government	Saving-Investment	ROW	ROE	Total
Activities	0	$(PX_{A_a} * QX_{A_c})$	0	0	0	0	0	0	0	$(PX_a * QX_a)$
Commodities	$(PINT_{A_a} * QINT_{A_a})$	0	0	$(PQ_c * QH_{c,h})$	0	$(PQ_c * QG_c)$	$\{(QINV_c + qds_t_c) * PQ_c\}$	$(pwe_c * QE_c * EXR)$	$(pwee_c * QE_c * EXRE)$	$(PQ_c * QQ_c)$
Factors	$\{WFA_{f_a} * QFS_{f_a} * (1 - UER)\}$	0	0	0	0	0	0	0	0	YF_f
Households	0	0	$(shif_{h,f} * YF_f)$	0	$TRII_{h,en}$	$TRII_{h,g}$	0	$(trnsfr_{h,row} * EXR)$	$(trnsfr_{h,roe} * EXRE)$	YI_h
Enterprises	0	0	$(shif_{en,f} * YF_f)$	0	0	$TRII_{en,g}$	0	$(trnsfr_{en,row} * EXR)$	$(trnsfr_{en,roe} * EXRE)$	YI_{en}
Government	$(ta_a * PA_a * QA_a)$ $(tva_a * PVA_a * QVA_a)$	$(tm_c * pwm_c * QM_c * EXR)$ $(te_c * pwe_c * QE_c * EXR)$ $(tq_c * PQ_c * QQ_c)$	$(tf_f * YF_f)$	$(TINS_h * YI_h)$	$(TINS_{en} * YI_{en})$	0	0	$(trnsfr_{g,row} * EXR)$	$(trnsfr_{g,roe} * EXRE)$	EG
Saving-Investment	0	0	0	$(MPS_h * YI_h)$	$(MPS_{en} * YI_{en})$	$(YG - EG)$	0	$(FSAV * EXR)$	$(FSAVE * EXRE)$	SAVE
Rest of World (ROW)	0	$(pwm_c * QM_c * EXR)$	$(trnsfr_{row,f} * EXR)$	0	0	0	0	0	0	ROW expenditure
Rest of EU (ROE)	0	$(pwe_c * QE_c * EXR)$	$(trnsfr_{roe,f} * EXR)$	0	0	0	0	0	0	ROE expenditure
Total	$(PA_a * QA_a)$	$(PQ_c * QQ_c)$	YF_f	YI_h	YI_{en}	YG	INVEST	Income from ROW	Income from ROE	

Source: McDonald and Thierfelder, 2009, adjusted by Author.

The value of domestic investment consists of fixed capital formation ($QINV_c * PQ_c$) and stock changes ($qdst_c * PQ_c$). The CGE-ILA model assumes that the commodity composition of fixed capital formation is fixed and the stock changes are invariant as well. Therefore, the value of fixed capital formation will vary with commodity prices (PQ_c) which the volume of fixed capital formation can vary both as a consequence of the volume of savings change or changes in exogenously determined parameters (McDonald, 2003). In the model, the account of domestic savings is made up of savings by households, enterprises, the government, and foreign savings from the rest of world and rest of EU ($FSAV$ & $FSAVE$).

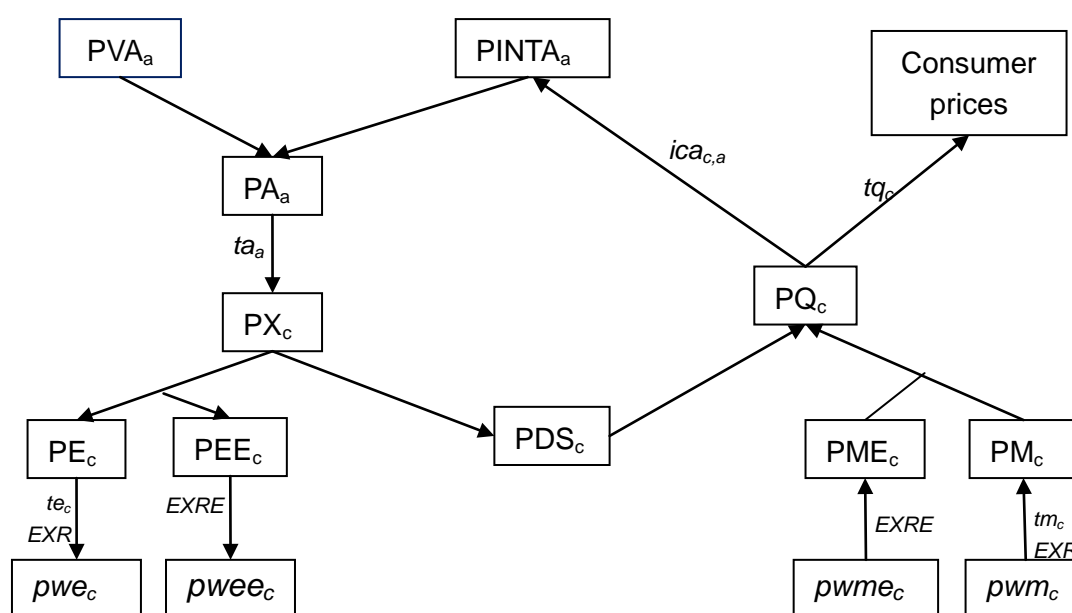
Incomes to the rest of the world account, equal to expenditures by the domestic economy in the rest of the world, consist of the values of imported commodities and factor services. On the other hand, expenditures by the rest of the world account, equal to incomes to the domestic economy from the rest of the world, consist of the values of exported commodities and transfers to domestic institutional accounts. All these transactions are subject to transformation by the exchange rate. The CGE-ILA model disaggregates the rest of the world account into ROW and ROE to see the different impacts of international labour immigration on trade between the UK and ROW and between the UK and ROE. Exchange rates are set different for both ROW and ROE, namely, EXR and EXRE.

5.3.1 Price Relationships of Marketed Commodities in CGE-ILA

Figure 5.1 provides further detail on the interrelationships of price for commodities and activities. The domestic output price of each activities (PA_a) is divided into the payments to aggregate value added (PVA_a), *i.e.*, the amount available to pay primary inputs, and aggregate intermediate input ($PINTA_a$). After paying the indirect taxes on

activity revenues (ta_a), the price per unit of output received by an activity (PA_a) is defined as the weighted average of the domestic producer prices (PX_c), where the weights are invariable. In the same way, domestic producer prices of commodities (PX_c) are defined as the weighted averages of the price received for commodities produced and sold domestically (PDS_c) and export markets (PE_c and PEE_c). The price of exports (PE_c) for ROW is defined as the world price of exports (pwe_c) and the exchange rate (EXR) less any exports taxes, which are decided by rates of taxes on exports (te_c). However, there are no trade taxes among EU member countries. Thus, the export prices from UK to other EU countries (PEE_c) only consider the difference of exchange rate.

Figure 5.1 Price Relationships for the CGE-ILA Model



Source: GTAP, adjusted by author.

The supply prices of the composite commodities (PQ_c) are defined as the weighted averages of the domestically produced commodities that are consumed domestically (PDS_c) and the domestic prices of imported commodities from the rest of world except EU (PM_c) and the domestic prices of imported commodities from the rest of EU (PME_c). PM_c is defined as the products of the world prices of commodities except EU (pwm_c)

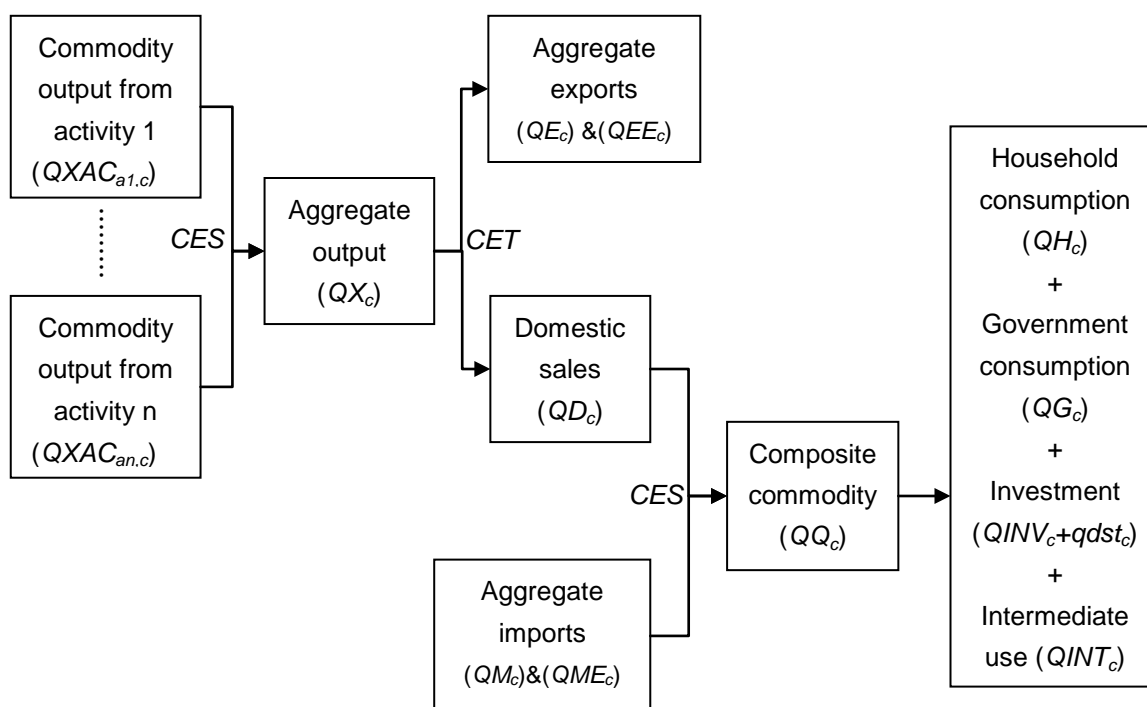
and the exchange rate (EXR), plus by import tariffs which are determined by rate of taxes on imports (tm_c). PME_c is similarly with PM_c but without the import tariffs. However, the composite commodity supply prices (PQ_c) do not include sales taxes, so the prices must be uplifted by sales taxes, which are determined by the rate of sales taxes (tq_c), to reflect the composite consumer price. Finally, the aggregated intermediate input price depends on the composite commodity price (PQ_c) and intermediate input coefficients ($ica_{c,a}$).

5.3.2 Quantity Relationships

With the exception of home-consumed output, all commodities (domestic output and imports) enter markets. Figure 5.2 shows the physical flows for marketed commodities along with the quantity variables. The first stage in the Figure 5.2 means that domestically produced commodities can come from multiple activities. A constant elasticity of substitution (CES) function is used as the aggregation function for aggregated output (QX_c) to aggregate the quantities of commodities produced by a number of different activities ($QXAC_{a,c}$). At the next stage, aggregated domestic output is allocated between exports (QE_c) & (QEE_c) and domestic sales (QD_c) on the assumption that suppliers maximize sales revenue for any given aggregate output level, subject to imperfect transformability between exports and domestic sales, expressed by a constant elasticity of transformation (CET) function (Lofgren *et al*, 2002).

Total domestic demand for the composite commodities (QQ_c) is made up of the sum of demands for consumption by households (QH_c) and government (QG_c), gross fixed investment ($QINV_c$), stock changes ($qdst_c$) and intermediate inputs. On the other hand, total supplies for the composite commodities are made up of imports (QM_c & QME_c) and domestic output (QD_c). This is also captured by a CES aggregation function.

Figure 5.2 Quantity Flows of Marketed Commodities



Source: adjusted from Lofgren *et al.*, (2002)

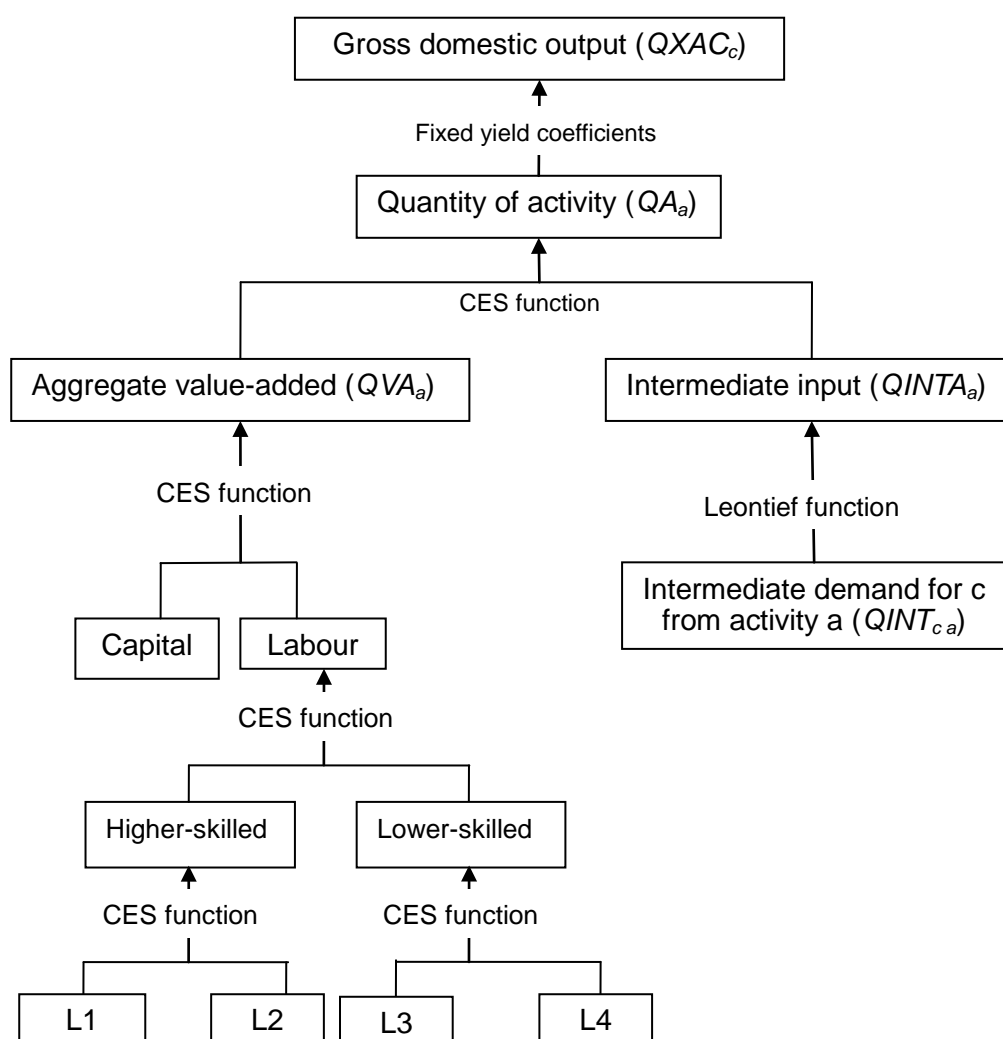
5.3.3 Production Relationships

Each firm (contained in production activities) is assumed to maximize its profit under perfect competition, defined as the difference between income and the cost of factors and intermediate inputs. The problem is equivalent to minimizing production costs subject to the production technology. Production relationships by activities are characterized by a four-level nested constant elasticity of substitution (CES) production functions, and the structure is illustrated in Figure 5.3. The factors at the end of any branch of the structure are all natural factors, and others are aggregates.

At the first level, activity output (QA_a) is specified by a CES aggregate of the quantities of value added (QVA_a) and aggregate intermediate inputs ($QINTA_a$). In addition, each

activity produces one or more commodities (QX_c) according to fixed yield coefficients. At the second level, aggregate value added is a CES aggregate of the quantities of primary factors demanded by each activity (QF_{fa}), where the primary inputs includes a natural factor, capital ($QF_{fcap a}$), and an aggregate labour ($QF_{fl a}$), whereas the aggregate intermediate input is a Leontief function of disaggregated intermediate input.

Figure 5.3 Structure of Four Level Production Activity



Source: adjusted from Lofgren *et al* (2002)

The third and fourth level CES nest production functions are focused on the aggregation of different types of labour force. The labour force in the UK is divided into four skilled level labour, which contains highly-skilled labour (L1), skilled labour (L2), semi-skilled

labour (L3) and unskilled labour (L4). Starting from the fourth level of the value added nests in Figure 5.3, highly-skilled labour (L1) and skilled labour (L2) that can be substituted form the aggregate higher-skilled labour, and semi-skilled labour (L3) and unskilled labour (L4)¹ that can be substituted form the lower-skilled labour. These two aggregate labours which are also substitutable form an aggregate labour force (QF_{fla}) by the third level nest.

In the model, the optimal combinations of each natural or aggregate factor in CES production functions are determined by first order conditions based on relative prices. The advantage of using such a nesting structure is that it avoids making the assumption that all natural factors are equally substitutable in the generation of value added (McDonald and Thierfelder, 2009). The structure in Figure 5.3 implicit presumes that capital and all different types of labour are not equally substitutable. Due to the reality of imperfect labour market, the quantity of labour supply equals the sum of labour demands from all activities plus unemployment.

5.4 Mathematical Statements of the Model

Based on IFPRI standard CGE model and STAGE_LAB enhance labour market model, this section will build up a complete system of equations for UK CGE-ILA model. In mathematical form, the model is an attempt to express the flows represented in the UK SAM as a set of simultaneous, nonlinear equations. The equations of the model are set out in four main ‘blocks’ which group the equation under the following headings ‘price block’, ‘production and trade block’, ‘institution block’ and ‘system constraint block’. The labour market imperfection is also introduced into the CGE-ILA model.

¹ Higher-skilled labour group includes highly-skilled (L1) and skilled (L2) labour; lower-skilled labour group includes semi-skilled (L3) and unskilled (L4) labour. These two aggregated groups will be applied through the whole thesis here after.

There are a series of conventions are adopted for the naming of variables and parameters. The sets of variables and parameters for UK CGE-ILA model are presented in Appendix 1.

- 1) All variables are in upper case. Exogenous variables are upper case letters with a bar, but endogenous variables without a bar.
- 2) The standard prefixes for variable names are: Q for commodity and factor quantities, P for commodity prices, W for factor prices, E for expenditure variables, and Y for income variables.
- 3) All variables have a matching parameter that identifies the value of the variable in the base period. These parameters are in upper case and carry a '0' suffix, and are used to initialise variables.
- 4) All parameters are in lower case, except those used to initialise variables.
- 5) Due to different treatments of model closures, exogenous and endogenous variables are not fixed in the model.

5.4.1 Price Block

One of the distinctive features of the CGE-ILA model is its detailed handling of prices. The Figure 5.1 in previous section has shown the process of how producer prices evolve to become the prices of final commodities. This block consists of twelve price equations, six of which refer to the treatment of trade.

Import price for ROW:

$$PM_c = pwm_c \cdot (1 + tm_c) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c} \quad c \in CM \quad (1a)$$

Import price for ROE:

$$PME_c = pwme_c \cdot EXRE + \sum_{c' \in CT} PQ_{c'} \cdot icme_{c'c} \quad c \in CM \quad (1b)$$

The domestic price of competitive imports is the price paid by domestic users for imported commodities (exclusive of the sales tax). Equation (1a) states that import price for ROW is the world price of imports (pwm_c) multiplied by exchange rate (EXR) and one plus import tariff rate (tm_c), and considering the transaction costs as well. Equation (1b) shows the import price for ROE, which is similar with equation (1a) but without the import tariff. These equations are only implemented for commodities CM that are imported.

Export price for ROW:

$$PE_c = pwe_c \cdot (1 - te_c) \cdot EXR - \sum_{c' \in CT} PQ_{c'} \cdot ice_{c'c} \quad c \in CE \quad (2a)$$

Export price for ROE:

$$PE_c = pwee_c \cdot EXRE - \sum_{c' \in CT} PQ_{c'} \cdot icee_{c'c} \quad c \in CE \quad (2b)$$

The export price in local-currency is the price received by domestic producers when they sell their output in export markets. Equation (2a) and (2b) are similar in structure to the equation (1a) and (1b). The main difference is that the tax and the cost of trade inputs reduce the price received by the domestic producers of exports. These equations are only implemented for domestic produced commodities CE that are exported.

Demand price of domestic non-traded goods:

$$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c} \quad c \in CD \quad (3)$$

Domestic agents consume composite consumption commodities (QQ) that are aggregates of domestically produced and imported commodities. The domestic demand price (PDD_c) is defined in equation (3) as the supply price plus the cost of trade inputs per unit of domestic sales of the commodity in question. There is an assumption of imperfect substitutability of goods produced domestically and those produced abroad, therefore composite supply of goods for domestic market from domestic production and

foreign markets is determined by Armington (CES) function (equation 29, 30 and 31), and for non-imported outputs or non-produced imports directly (equation 32). Consumers minimize the cost of the purchase of a determined quantity of the composite good, based on their relative prices.

Absorption:

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + PM_c \cdot QM_c + PME_c \cdot QME_c \quad c \in (CD \cup CM) \quad (4)$$

Absorption is total domestic spending on a commodity at domestic demander prices. Equation (4) shows prices for domestic market are endogenous, which is determined by supply and demand. Absorption is expressed as the sum of spending on domestic output and imports at the demand prices, PDD , PM and PME , but exclude the commodity sales tax. This equation is implemented for all commodities that are produced and consumed domestically (CD) and for all commodities that are imported (CM).

Market output value:

$$PX_c \cdot QX_c = PDS_c \cdot QD_c + PE_c \cdot QE_c + PEE_c \cdot QEE_c \quad c \in CX \quad (5)$$

Domestically produced commodity (QX_c) are supplied to either or both the domestic and foreign markets. Therefore, the marketed output value at producer prices is stated as the sum of the values of domestic sales and exports. Domestic sales and exports are valued at the prices received by the suppliers, PDS_c , PE_c and PEE_c . Quantity demand for domestic and foreign markets is determined by Leontief function of intermediate inputs (equation 26 and 27), and allocated by equation (25). This equation is implemented for all commodities that are produced domestically.

Activity price:

$$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac} \quad a \in A \quad (6)$$

Aggregate intermediate input price:

$$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca} \quad a \in A \quad (7)$$

Activity price is determined by equation (6) and price of aggregate intermediate input by equation (7). Equation (6) allows the fact that activities may produce multiple commodities. Equation (7) shows that aggregate intermediate input price depends on composite commodity prices and intermediate input coefficients.

Activity revenue and costs:

$$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a \quad a \in A \quad (8)$$

The value of activity output can be expressed as the sums of the expenditures on inputs after allowing for the production taxes (ta_a). Given the above definitions of PA and $PINTA$, equation (8) implicitly defines the value-added price, PVA .

Consumer price index:

$$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c \quad (9)$$

Producer price index for non-traded market output:

$$DPI = \sum_{c \in C} PDS_c \cdot dwts_c \quad (10)$$

The price block is completed by two price indices that can be used for price normalisation. Equation (9) is for the consumer price index (CPI), which is defined as a weighted sum of composite commodity prices (PQ_c) in the current period, where the weights are the shares of each commodity in total demand ($cwts_c$). The domestic producer price index (DPI) is defined in equation (10) as the supply prices for

domestically produced commodities (PDS_c) with shares of the value of domestic output for the domestic market ($dwtsc$).

5.4.2 Production and Trade Block

The production and trade block covers four categories: 1) domestic production and input use, and the CGE-ILA uses a four-level nested CES production function; 2) the allocation of domestic output to home consumption, the domestic market, and exports; 3) the aggregation of supply to the domestic market (from imports and domestic output sold domestically); and 4) the definition of the demand for trade inputs that is generated by the distribution process (Lofgren *et al*, 2002). As noted in the former section about the production relationships (Figure 5.3), the equations for this block are shown as follow.

CES aggregation functions for level 1 of production nest:

$$QA_a = \alpha_a^a \cdot (\delta_a^a \cdot QVA_a^{-\rho_a^a} + (1 - \delta_a^a) \cdot QINTA_a^{-\rho_a^a})^{-\frac{1}{\rho_a^a}} \quad a \in ACES \quad (11)$$

Value-added intermediate-input quantity ration:

$$\frac{QVA_a}{QINTA_a} = \left(\frac{PINTA_a}{PVA_a} \cdot \frac{\delta_a^a}{1 - \delta_a^a} \right)^{\frac{1}{1+\rho_a^a}} \quad a \in ACES \quad (12)$$

Equation (11) and (12) display CES technology production functions for first level nest, which explain the output by an activity (QA_a) is determined by selecting the optimal combination of value-added (QVA_a) and intermediate inputs ($QINTA_a$). α_a^a is the efficiency parameter, δ_a^a is the share parameter, and ρ_a^a is the exponent of elasticity of

substitution².

CES aggregation functions for level 2 of production nest:

$$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F1ST} \delta_{f1st a}^{va} \cdot QF_{f1st a}^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}} \quad a \in A \quad (13)$$

$$\begin{aligned} & WF_{f1st} \cdot \overline{WFDIST}_{f1st a} \\ &= PVA_a \cdot (1 - tva_a) \cdot QVA_a \cdot \left(\sum_{f \in F1ST} \delta_{f1st a}^{va} \cdot QF_{f1st a}^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{f a}^{va} \\ &\cdot QF_{f1st a}^{-\rho_a^{va}-1} \quad a \in A, \quad f \in F1ST \end{aligned} \quad (14)$$

The production function for quantity of value-added (QVA_a) is a second level CES function of disaggregated factor quantities, aggregated labour ($QF_{fl a}$) and capital ($QF_{fcap a}$), as shown in equation (13). ρ_a^{va} is exponent of elasticity of substitution, α_a^{va} is the efficiency parameter, and $\delta_{f1st a}^{va}$ is the share parameter.

According to equation (14), the associated first order conditions for profit maximisation determine the wage rate of factors (WF), where the ratio of factor payments to factor f from activity a ($WFDIST$) are included to allow for non-homogenous factors, and is derived directly from the first order condition for profit maximisation as equalities between the wage rates for each factor in each activity and the values of the marginal products of those factors in each activity (McDonald, 2003). The equation (14) implies that both the activity outputs (QA_a) and factor demands are solved simultaneously through the profit maximisation process.

² For CES functions, $\rho = 1/\sigma - 1$, where σ is the elasticity of substitution. Therefore, the higher the value of σ , the smaller the value of ρ and the larger the optimal change in the ratios between the quantities of value-added and the intermediate input aggregate in response to changes in their relative prices.

CES aggregation functions for level 3 of aggregate labour production nest:

$$QF_{f1l a} = \alpha_{f1l a}^{lab} \cdot \left(\sum_{f \in F1L} \delta_{f1l a}^{lab} \cdot QF_{f1l a}^{-\rho_{f1l a}^{lab}} \right)^{-\frac{1}{\rho_{f1l a}^{lab}}} \quad a \in A \quad (15)$$

$$\begin{aligned} & WF_{f2nd} \cdot \overline{WFDIST}_{f2nd a} \\ &= WF_{f1l a} \cdot \overline{WFDIST}_{f1l a} \cdot \left(\sum_{f \in F2ND} \delta_{f1l f2nd a}^{lab} \cdot QF_{f2nd a}^{-\rho_a^{lab}} \right)^{-1} \\ & \cdot \delta_{f1l f2nd a}^{lab} \cdot QF_{f2nd a}^{-\rho_{f1l a}^{lab}-1} \quad a \in A, \quad f \in F2ND \end{aligned} \quad (16)$$

Equation (15) is the third level CES aggregation function, which explains the relationship between higher-skilled aggregate labour and lower-skilled aggregate labour.

The wage ($WF_{f2nd} \cdot \overline{WFDIST}_{f2nd a}$) of two aggregate labours are determined by profit maximisation, as shown in equation (16).

CES aggregate functions for Level 4 of higher-skilled aggregate labour production nest:

$$QF_{f2l a} = \alpha_{f2l a}^{lsk} \cdot \left(\sum_{f \in F2L} \delta_{f2l a}^{lsk} \cdot QF_{f2l a}^{-\rho_{f2l a}^{lsk}} \right)^{-\frac{1}{\rho_{f2l a}^{lsk}}} \quad a \in A \quad (17)$$

$$\begin{aligned} & WF_{flsk} \cdot \overline{WFDIST}_{flsk a} \\ &= WF_{f2l a} \cdot \overline{WFDIST}_{f2l a} \cdot \left(\sum_{f \in FLSK} \delta_{f2l flsk a}^{lsk} \cdot QF_{flsk a}^{-\rho_a^{lsk}} \right)^{-1} \\ & \cdot \delta_{f2l flsk a}^{lsk} \cdot QF_{flsk a}^{-\rho_{f2l a}^{lsk}-1} \quad a \in A, f \in FLSK \end{aligned} \quad (18)$$

CES aggregation functions for Level 4 of lower-skilled aggregate labour production

nest:

$$QF_{f3l a} = \alpha_{f3l a}^{lusk} \cdot \left(\sum_{f \in F3L} \delta_{f3l a}^{lusk} \cdot QF_{f3l a}^{-\rho_{f3l a}^{lusk}} \right)^{-\frac{1}{\rho_{f3l a}^{lusk}}} \quad a \in A \quad (19)$$

$$\begin{aligned} & WF_{flusk} \cdot \overline{WFDIST}_{flusk a} \\ &= WF_{f3l a} \cdot \overline{WFDIST}_{f3l a} \cdot \left(\sum_{f \in FLUSK} \delta_{f3l flusk a}^{lusk} \cdot QF_{flusk a}^{-\rho_a^{lusk}} \right)^{-1} \\ & \cdot \delta_{f3l flusk a}^{lusk} \cdot QF_{flusk a}^{-\rho_{f3l a}^{lusk} - 1} \quad a \in A, f \in FLUSK \end{aligned} \quad (20)$$

In the fourth level CES aggregation functions, equation (17) and (19) are used to aggregate highly-skilled labour (L1) and skilled labour (L2) to form the higher-skilled aggregate labour (FLSK) and aggregate semi-skilled labour (L3) and unskilled labour (L4) to form the lower-skilled aggregate labour (FLUSK). Equation (18) and (20) define the profit maximisation of them.

In this four level CES nest production functions, the efficiency parameter (α) and the share parameter (δ) are calibrated from the process of modelling, while the exponent of elasticity of substitution (ρ) which is calculated from the elasticity of substitution (σ) is given from outside sources and will be discussed in the section 6.6.

Disaggregated intermediate input demand:

$$QINT_{ca} = ic_{ca} QINT_a \quad a \in A, c \in C \quad (21)$$

For each activity, intermediate commodity demand ($QINT_{ca}$) is defined via a standard Leontief formulation as the product of fixed (Leontief) input coefficients of demand multiplied by the quantity of aggregate intermediate input, as shown in equation (21).

Commodity production and allocation:

$$QXAC_{ac} + \sum_{h \in H} QHA_{ach} = \theta_{ac} \cdot QA_a \quad a \in A, c \in CX \quad (22)$$

Equation (22) shows the allocation of marketed output quantity. On the right-hand side, production quantities, disaggregated by activity, are defined as outputs multiply activity levels. On the left-hand side, these quantities are allocated to market sales and home consumption. Note that this equation permits (i) any commodity to be produced by one or more activities and (ii) any activity to produce one or more commodities (Lofgren *et al*, 2002).

Output aggregation function:

$$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}}} \quad c \in CX \quad (23)$$

First-order condition for output aggregation function:

$$PXAC_{ac} = PX_c \cdot QX_c \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}-1} \quad a \in A, c \in CX \quad (24)$$

Using CES aggregator function, equation (23) aggregates the marketed output levels of the different activities ($QXAC_{ac}$) to form the domestic marketed production of any commodity (QX_c). Here, α_c^{ac} is the shift parameter, δ_{ac}^{ac} is the share parameter and ρ_c^{ac} is the elasticity exponent. The matching first-order condition for the optimal combination of commodity outputs from each activity source is inversely related to the activity-specific price, which is given by equation (24).

Output transformation (CET) function:

$$QX_c = a_c^t \cdot \left(\delta_c^t \cdot QE_c^{\rho_c^t} + \delta_c^{te} \cdot QEE_c^{\rho_c^t} + (1 - \delta_c^t - \delta_c^{te}) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \quad c \in (CE \cap CD) \quad (25)$$

Quantity of export to the ROW:

$$QE_c = QD_c \cdot \left(\frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^t - \delta_c^{te}}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \quad c \in (CE \cap CD) \quad (26)$$

Quantity of export to the ROE:

$$QEE_c = QD_c \cdot \left(\frac{PEE_c}{PDS_c} \cdot \frac{1 - \delta_c^t - \delta_c^{te}}{\delta_c^{te}} \right)^{\frac{1}{\rho_c^t - 1}} \quad c \in (CE \cap CD) \quad (27)$$

Trade relationships are modelled using the Armington/CET assumption of imperfect substitutability between domestic and foreign commodities. Equations (25), (26) and (27) address the allocation of marketed domestic output (QX_c), to three destinations: domestic sales and exports to ROW and ROE. Equation (25) reflects the assumption of imperfect transformation between these three destinations by way of CET function, with shift parameter (a_c^t), commodity specific share parameters (δ_c^t for ROW and δ_c^{te} for ROE), and elasticity exponent (ρ_c^t)³.

Equation (26) and (27) defines the optimal quantities of exports to ROW and ROE, separately. Equations (5), (25), (26) and (27) constitute the first-order conditions for maximization of producer revenues given the three prices and subject to the CET function and a fixed quantity of domestic output. The optimum ratios of exports to domestic demand are defined in relation to the relative prices of exported (PE_c or PEE_c) and domestically supplied (PDS_c) commodities. Therefore, the increase in the export-domestic price ration would generate an increase in the quantity of exports.

Output transformation for domestically sold outputs without exports and for exports without domestic sales:

$$QX_c = QD_c + QE_c + QEE_c \quad c \in (CD \cap CEN) \cup (CE \cap CDN) \quad (28)$$

³ For CET function, $\varepsilon = \frac{1}{\rho - 1}$, where ε is the elasticity of transformation and $\rho (>1)$ is the exponent.

This equation (28) replaces the CET function for domestically produced commodities that do not have both exports and domestic sales. It allocates the entire output volume to one of these three destinations.

Composite supply (Armington) function:

$$\begin{aligned}
 QQ_c = \alpha_c^q \cdot & \left(\delta_c^q \cdot QM_c^{-\rho_c^q} + \delta_c^{qe} \cdot QME_c^{-\rho_c^q} + (1 - \delta_c^q - \delta_c^{qe}) \right. \\
 & \left. \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}} \quad c \in (CM \cap CD)
 \end{aligned} \tag{29}$$

Quantity of imports from the ROW:

$$QM_c = QD_c \cdot \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \delta_c^q - \delta_c^{qe}} \right)^{\frac{1}{1+\rho_c^q}} \quad c \in (CM \cap CD) \tag{30}$$

Quantity of imports from the ROE:

$$QME_c = QD_c \cdot \left(\frac{PDD_c}{PME_c} \cdot \frac{\delta_c^{qe}}{1 - \delta_c^q - \delta_c^{qe}} \right)^{\frac{1}{1+\rho_c^q}} \quad c \in (CM \cap CD) \tag{31}$$

The domestic supply equations are modelled by using CES functions and associated first order conditions to determine the optimum combination of supplies from domestic and foreign (import) producers (McDonald, 2003). The domestic supplies of the composite commodities (QQ_c) are aggregated by a CES function (equation 29), which contains domestic production supplied to the domestic market (QD_c) and imports from ROW (QM_c) and ROE (QME_c). When the domain of this function is limited to commodities that are both imported and produced domestically, it is often called an ‘Armington’ function, named after the originator of the idea of using a CES function for

this purpose (Lofgren *et al*, 2002). α_c^q is the shift parameter, δ_c^q and δ_c^{qe} are the share parameters, and ρ_c^q is the elasticity exponent.

Equation (30) and (31) define the optimal mix between imports (QM_c and QME_c) and domestic output (QD_c) in relation to the relative prices of imported (PM_c and PME) and domestic supplied (PDD_c) commodities. These two equation show that an increase in the domestic-import price ration would generate an increase in the quantity of imports. Together, equations (4), (25), (26), and (27) constitute the first-order conditions for cost-minimization given the three prices and subject to the Armington function and a fixed quantity of the composite commodity.

Composite supply for non-imported outputs and non-produced imports:

$$QQ_c = QD_c + QM_c + QME_c \quad c \in (CD \cap CMN) \cup (CM \cap CDN) \quad (32)$$

However, equation (29) is only defined for commodities that are both produced domestically and imported. While this condition might be satisfied for the majority of commodities, it is also necessary to cover those cases where commodities are produced domestically but not imported, and those cases where commodities are not produced domestically but imported. Therefore, the Armington function (29) is replaced by equation (32) for the union of commodities that have either imports or domestic sales of domestic output but not both.

Demand for transactions services:

$$QT_c = \sum_{c' \in C'} (icm_{cc'} \cdot QM_{c'} + icme_{cc'} \cdot QME_{c'} + ice_{cc'} \cdot QE_{c'} + icee_{cc'} \cdot QEE_{c'} + icd_{cc'} \cdot QD_{c'}) \quad c \in CT \quad (33)$$

The equation (33) shows that total demand for trade inputs (QT_c) is the sum of the demands for these inputs that are generated by imports (QM_c and QME_c), exports (QE_c and QEE_c), and domestic market sales (QD_c). In all three cases, fixed quantities of one

or more transactions service inputs are required per unit of the traded commodity (Lofgren *et al*, 2002).

5.4.3 Institution block

The CGE-ILA model contains four main economic institutions, namely, households, enterprises, government and the rest of world (divided into ROW and ROE). The equations in this block describe the income, expenditure and mutual transfer payments among these institutions.

Factor income:

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} + trnsfr_{f_{row}} \cdot EXR + trnsfr_{f_{roe}} \cdot EXRE \quad f \in F \quad (34)$$

Equation (34) shows that there are two main sources of income for factors. First, there are sum of activity payments to factor accounts, such as domestic value added, and second there are overseas payments to domestic factors for services used overseas, the value of these are assumed fixed in terms of foreign currency.

Domestic institutional factor incomes:

$$YIF_{if} = shif_{if} \cdot [(1 - tf_f) \cdot YF_f - trnsfr_{row_f} \cdot EXR - trnsfr_{roe_f} \cdot EXRE] \quad i \in INSD, f \in F \quad (35)$$

Before distributing factor incomes to the institution that supply factor services allowance is made for factor taxes and transfers to overseas, so that factor income for distribution (YIF_{if}) is defined in equation (35).

Income of domestic nongovernment institutions:

$$\begin{aligned}
YI_i &= \sum_{f \in F} YIF_{if} + \sum_{c' \in INSDNG} TRII_{i i'} + trnsfr_{i gov} \cdot \overline{CPI} + trnsfr_{i row} \cdot \\
&EXR + trnsfr_{i roe} \cdot EXRE \qquad i \in INSDG \qquad (36)
\end{aligned}$$

Households and enterprises are two domestic non-government institutions. Equation (36) defines that households and enterprises receive income 1) from the sum of factor incomes (equation 35); 2) in form of transfers from other domestic non-government institutions (infra-institutional transfers, defined below in equation (37)); 3) transfers from the government; and 4) in form of transfers from abroad (ROW and ROE).

Infra-institutional transfers:

$$TRII_{i i'} = shii_{i i'} \cdot (1 - MPS_{i'}) \cdot (1 - TINS_{i'}) \cdot YI_{i'} \qquad i \in INSDNG \qquad (37)$$

Transfers between domestic nongovernment institutions are paid as fixed shares of the total institutional incomes net of direct taxes and savings. The values of MPS and $TINS$ are defined in separate equations and will be discussed in system constraint block.

Household consumption expenditures:

$$EH_h = (1 - \sum_{i \in INSDNG} shii_{i h}) \cdot (1 - MPS_h) \cdot (1 - TINS_h) \cdot YI_h \qquad h \in H \qquad (38)$$

Equation (38) defines households' expenditures that households use their income to pay direct taxes, savings and make transfers to other domestic non-government institutions, and the remaining income is spent on the consumption of marketed commodities, for which only households need among the domestic non-government institutions.

Household consumption spending on marketed commodities:

$$\begin{aligned}
PQ_c \cdot QH_{ch} &= PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma_{a c'h}^h \right) \\
&\qquad c \in C, h \in H \qquad (39)
\end{aligned}$$

Household consumption spending on home commodities:

$$\begin{aligned}
 & PXAC_{ac} \cdot QHA_{ach} \\
 &= PXAC_{ac} \cdot \gamma_{ach}^h + \beta_{ach}^h \\
 &\cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma_{ac'h}^h \right) \\
 & \qquad \qquad \qquad a \in A, c \in C, h \in H \qquad (40)
 \end{aligned}$$

Household consumption is allocated across commodities according to linear expenditure system (LES) demand functions, which is derived from maximization of a ‘Stone-Geary’ utility function (Pouliakas *et al.*, 2008). Equation (39) and (40) define that households consume two types of commodities: 1) marketed commodities and 2) home production.

Investment demand:

$$QINV_c = \overline{IADJ} \cdot \overline{qinv}_c \qquad c \in C \qquad (41)$$

Fixed investment demand is defined as the base-year quantity multiplied by an adjustment factor (\overline{IADJ}), and is defined exogenously in CGE-ILA model.

Government consumption demand:

$$QG_c = \overline{GADJ} \cdot \overline{qg}_c \qquad c \in C \qquad (42)$$

Similarly, government consumption demand in equation (42) is also defined as the base-year quantity multiplied by an adjustment factor (\overline{GADJ}). This factor is also exogenous and, hence, the quantity of government consumption is fixed.

Government revenue:

$$\begin{aligned}
YG = & \sum_{i \in INSDNG} TINS_i \cdot YI_i + \sum_{f \in F} tf_f \cdot YF_f + \sum_{a \in A} tva_a \cdot PVA_a \cdot QVA_a \\
& + \sum_{a \in A} ta_a \cdot PA_a \cdot QA_a + \sum_{c \in CM} tm_c \cdot pwm_c \cdot QM_c \cdot EXR \\
& + \sum_{c \in CE} te_c \cdot pwe_c \cdot QE_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YIF_{gov f} \\
& + trnsfr_{gov row} \cdot EXR + trnsfr_{gov roe} \cdot EXRE
\end{aligned} \tag{43}$$

Equation (43) shows that the sources of income to the government account are complex. Government revenue firstly accrues revenues from direct taxes ($TINS_i$), factor taxes (tf_f), value-added tax (tva_a), activity taxes (ta_a), import tariffs from ROW (tm_c), export duties to ROW (te_c), and sales taxes (tq_c). In addition, the government receives income from factor incomes and transfers from abroad.

Government Expenditure:

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i gov} \cdot \overline{CPI} \tag{44}$$

Total government spending is defined in equation (44) as equal to the sum of expenditure by government on consumption demand at current price, plus transfers to other institutions.

5.4.4 System constraint block

The CGE-ILA model for UK needs to be ‘closed’ with respect to four macroeconomic balances: the factor market balance, the (current) government balance, the external balance (the current account of the balance of payments, which includes the trade balance), and the Savings-Investment balance.

Factor markets balance:

$$\sum_{a \in A} QF_{flab} = \overline{QFS_{flab}} \cdot (1 - UER_{flab}) \quad flab \in FLAB \quad (45a)$$

$$\sum_{a \in A} QF_{fcap} = \overline{QFS_{fcap}} \quad fcap \in FCAP \quad (45b)$$

In the neoclassical standard model version, the factor endowments are exogenously determined and assumed full capital usage and full employment. However, in reality, there is unemployment in the UK, no matter voluntary or involuntary. Equation (45a) defines that total quantity labour demanded is equal to the total quantity labour supplied minus unemployment. Equation (45b) imposes equality between the total capital demand and total capital supply.

Composite commodity markets balance:

$$QQ_c = \sum_{c \in C} QINR_{ca} + \sum_{h \in H} QH_{ch} + QG_c + QINV_c + qdst_c + QT_c \quad c \in C \quad (46)$$

Equation (46) describes market clearing for the composite commodity market. The quantity of supplied composite commodities (QQ_c) is equal to total of domestic demands for composite commodities, which consists of intermediate demand ($QINT_{ca}$), households' demand (QH_{ch}), government demand (QG_c), trade input use (QT_c) and final investment demand ($QINV_c$) and stock changes ($qdst_c$). The composite commodity supply (QQ_c) drives demands for domestic marketed output (QD_c) and imports (QM_c & QME_c). The market-clearing variables are the quantities of import supply, for the import side, and the two interrelated domestic prices, PDD and PDS , for domestic market output (Lofgren *et al*, 2002).

Current-account balance for the ROW, in foreign currency:

$$\sum_{c \in CM} pwm_c \cdot QM_c + \sum_{f \in F} trnsfr_{row f} = \sum_{c \in CE} pwe_c \cdot QE_c + \sum_{i \in INSD} trnsfr_{i row} + \overline{FSAV} \quad (47a)$$

Current-account balance for the ROE, in foreign currency:

$$\begin{aligned} \sum_{c \in CM} pwme_c \cdot QME_c + \sum_{f \in F} trnsfr_{roe f} \\ = \sum_{c \in CE} pwee_c \cdot QEE_c + \sum_{i \in INSD} trnsfr_{i roe} + \overline{FSAVE} \end{aligned} \quad (47b)$$

The current-account balance, which is expressed in foreign currency, imposes equality between the country's spending and its earning of foreign exchange. The balance of foreign account in CGE-ILA model is defined as a current account balance separately for both regions of the disaggregated foreign world (equation 47a and 47b).

Government balance:

$$YG = EG + GSAV \quad (48)$$

The government balance imposes equality between current government revenue (YG) and the sum of current government expenditures (EG) and savings ($GSAV$). Savings for government may be negative.

Direct institutional tax rates:

$$TINS_i = \overline{tins}_i \cdot (1 + \overline{TINSADJ} \cdot tins01_i) + \overline{DTINS} \cdot tins01_i \quad i \in INSDNG \quad (49)$$

Equation (49) defines the direct tax rates of domestic non-government institutions. In

CGE-ILA model, all variables on the right-hand side are fixed, in effect fixing the values for the direct tax rate variable for all institutions. In this setting, government savings is the endogenous variable that clears the government balance.

Institutional savings rates:

$$MPS_i = \overline{mps}_i \cdot (1 + \overline{MPSADJ} \cdot mps01_i) + \overline{DMPS} \cdot mps01_i \quad i \in INSDNG \quad (50)$$

Equation (50) defines the savings rates of domestic nongovernment institutions. Its structure is the same as that of equation (49). Whether one or none of the variables $MPSADJ$ and $DMPS$ is flexible depends on the closure rule for the Savings-Investment balance.

Savings-investment balance:

$$\begin{aligned} \sum_{i \in INSDNG} MPS_i \cdot (1 - TINS_I) \cdot YI_i + GSAV + EXR \cdot \overline{FSAV} + EXRE \cdot \overline{FSAVE} \\ = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c + WALRAS \end{aligned} \quad (51)$$

The final account to be cleared is the capital account that total savings and total investment have to be equal. On the left side of equation (51) shows that total savings is the sum of savings from domestic non-government institutions, the government, and foreign world. The right side of equation (51) shows that total investment is the sum of the values of fixed investment and stock changes. However, a slack variable, $WALRAS$, is included in this market clearing condition. It returns a zero value when the model is fully closed and all markets are cleared.

Total absorption:

$$\begin{aligned}
TABS = & \sum_{h \in H} \sum_{c \in C} PQ_c \cdot QH_{c h} + \sum_{a \in A} \sum_{c \in C} \sum_{h \in H} PXAC_{a c} \cdot QHA_{a c h} + \sum_{c \in C} PQ_c \cdot QG_c \\
& + \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c
\end{aligned} \tag{52}$$

Ratio of investment to absorption:

$$INVSHR \cdot TABS = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c \tag{53}$$

Ratio of government consumption to absorption:

$$GOVSHR \cdot TABS = \sum_{c \in C} PQ_c \cdot QG_c \tag{54}$$

There are three additional equations are introduced to permit additional savings-investment closures, for total absorption as GDP at market prices plus imports minus exports (equation 52), ratio of investment to absorption (equation 53), and ration of government consumption to absorption (equation 54).

5.4.5 Labour Market Imperfection

The standard factor market assumption leaves no room for the possibility of unemployment. Therefore, in order to reflect the reality of labour market in the UK, CGE-ILA model is enhanced by considering imperfect labour markets and resulting unemployment. Considering unemployment yields two major advantages. First, the specification of the labour market reflects reality in detail. Second, it is very helpful to do the analysis of the impact of different types of international labour immigration on social welfare of households and UK industries. Data on unemployment for different skilled types of labour is provided by International Labour Organisation (ILO) for UK 2004.

Unemployment is incorporated into the model by using the ‘wage curve’, first introduced by Blanchflower and Oswald (1995). A wage curve captures the relationship between the level of unemployment and the level of real wages and describes how the price of labour is affected by the unemployment rate. The wage curve for each type of labour implies a negative relationship between the unemployment rate and the real wage, i.e. high (low) unemployment leads to lower (higher) wages. Taking into account the idea of non-competitive labour markets, this negative correlation has at least two micro-economic reasons.

- 1) The correlation can be explained by the efficiency wage theory. Efficiency wage models are based on Solow (1979) and state that firms may set wages above market level, assuming that real wage levels affect productivity. In a situation where the unemployment rate is high, firms can reduce the rate of pay because the workers are afraid of losing their jobs. Therefore the workers will still put a high effort to working even though the wage is relatively low.
- 2) Drawing on wage bargaining theory based on McDonald and Solow (1981), unions generally bargain for wages above market level. High unemployment can hamper the ability of unions to claim high wages. The level of unemployment may also affect the union’s preferences in wage bargaining. If a union’s objective function includes both employed members as well as unemployed (members or non-members) it may alter its objective: Instead of high wages for its employed members, employment opportunities in favour of the unemployed members or non-members become bargaining an objective at the cost of somewhat lower wages.

Blanchflower and Oswald (1995) argued that the conventional unemployment theories illustrated by Phillips curve and Harris-Todaro model (Harris and Todaro, 1970) were misleading. The former describes the relation between the wage growth rate and

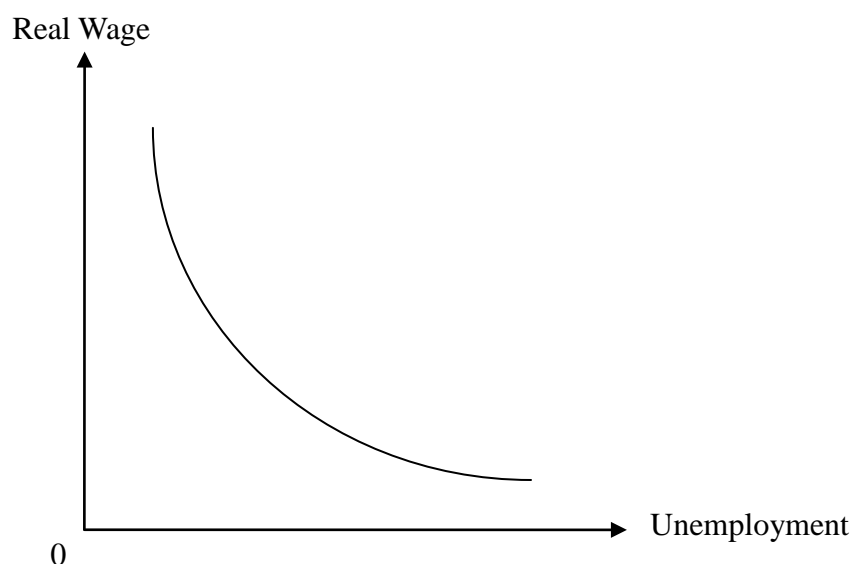
unemployment. In contrast to the wage curve, the Harris-Todaro model suggests a reverse relationship that high wage regions are likely to become regions with high unemployment as well. The Harris-Todaro model does not draw upon neoclassical unemployment where unemployment is caused by high wages above marginal productivity (Kuster *et al*, 2007). The wage curve implies that labour is not perfectly mobile between regions, and is a better representation of the wage-unemployment relationship. Therefore, the wage curve theorem suites the CGE-ILA model settings.

Blanchflower and Oswald (1995) identify a typical wage curve formula by:

$$\ln W = \beta \ln U \quad (55)$$

where W is the real wage, U is the unemployment rate. The parameter β is always negative and reflects the unemployment elasticity of the wage. It describes the marginal change in the level of real wages following a change in the unemployment rate, as shown in Figure 5.4.

Figure 5.4 The Wage Curve



Source: Blanchflower and Oswald (1995)

Blanchflower and Oswald (1995) argue that the result of the elasticity parameter β is

approximately -0.1 for any region or country. An increase of unemployment by one percent is associated with a decrease of wages by 0.1 percent.

Since the introduction of wage curve, it has been formulated and adopted into CGE modelling in many areas. For example, Carneiro and Abbache (2003), Brucker and Kohlhaas (2004) and Baas and Brucker (2008) all use the wage curve in the context of trade and international labour migration. Models that use the wage curve in the analysis of energy policy and sustainability can be found in Bohringer and Loschel (2006) and Kuster et al. (2007). The wage curve has also been used in the analysis of poverty and the distribution of income by Davies and Rattso (2000), Cury *et al.* (2004) and Magubu and Chitiga (2007).

In order to obtain the wage equation relevant for implementing a wage curve and its associated involuntary unemployment into the CGE-ILA model, the equation (55) needs further adjustment. In the CGE-ILA model for the UK, the elasticity parameter is further fixed at -0.13 by Baas and Brucker (2008). Therefore, the wage curve function for UK labour market is:

$$\ln WR_{flab} = -0.13 \ln UER_{flab} \quad (56)$$

Where WR_{flab} is the real wage for different skill types of labour, UER_{flab} is the unemployment rate for corresponding labour. Taking the antilog yields:

$$WR_{flab} = UER_{flab}^{-0.13} \quad (57)$$

By the definition, the real wage (WR_{flab}) is the nominal wage based on a consumer price index (CPI):

$$WR_{flab} = WF_{flab} / CPI \quad (58)$$

Thus, equation (W3) can be rewritten as:

$$WF_{flab} / CPI = UER_{flab}^{-0.13} \quad (59)$$

For an implementation into CGE-ILA model, the wage equation needs further adjustment because the benchmark equilibrium with relative prices for labour and for the consumption bundle being equal to one is not reported by equation (59). In order to have benchmark consistency initial unemployment rates have to be taken into account, as well as benchmark prices for labour and consumption indices, which both have to be unity (Kuster *et al.* 2007). Thus, a scaling parameter is added to equation (59), as follow:

$$\frac{WF_{flab}}{CPI} = \frac{\frac{WF_{flab}^0}{CPI_0}}{UER_{flab}^0^{-0.13}} \cdot UER_{flab}^{-0.13} \quad (60)$$

The parameter UER_{flab}^0 is the initial unemployment rate, whereas UER_{flab} is the unemployment rate endogenously computed by the wage equation. Both WF_{flab}^0 and CPI_0 are unity and calculated from the benchmark data, UK SAM 2004 (described in the next chapter). Equation (58) and (60) are used in the CGE-ILA model.

5.5 Closure Rules in CGE-ILA Model

Closure rules in the CGE model serve as tools to balance the number of endogenous variables equation making technically possible to reach a solution. Selection of a closure significantly affects model results, because the term closure refers to the choice of endogenous and exogenous variables in the CGE model. This determines which variables can or cannot be adjusted to achieve a new equilibrium, and the equilibrium outcomes are sensitive to the choice of closure.

All simulated price and income changes should be interpreted as changes regarding the numeraire price index (Lofgren *et al.*, 2002). The index for domestic producer prices (DPI) in the UK is selected as the numeraire price for the CGE-ILA model. Therefore, consumer price index (CPI) is set flexible.

The closures of the savings-investment balance are either investment-driven or savings-driven. In line with the approach used by other authors modelling opening economies in the medium to long run (Julia-Wise *et al.*, 2002), CGE-ILA model adopts a savings-driven closure that domestic non-government savings are assumed to be a fixed proportion of disposable income. Therefore, marginal savings propensities (*DMPS*), savings rate scaling (*MPSADJ*) and Government demand quantity adjustment factors (*GADJ*) are fixed, but investment scaling factor (*IADJ*), investment share of absorption (*INVSHR*) and government consumption share of absorption (*GOVSHR*) are endogenous.

In terms of the external balance, which is expressed in foreign currency, is achieved through flexible exchange rate while the foreign savings are assumed fixed. This implies that the real exchange rate for both ROW (*EXR*) and ROE (*EXRE*) are endogenous, while foreign savings (*FSAV* and *FSAVE*) are exogenous.

The government balance in CGE-ILA model is achieved by allowing government savings (*GSAV*) to adjust endogenously within the model while all direct tax rates are fixed.

For factor-market closure, the labour force are assumed to be fully employed and mobile between activities (*FMOBFE*), but capital is set as fully employed and activity-specific (*FACTFE*). Factor price (WF_f) is the market-clearing variable for each factor. Therefore, quantity of factor supply (QFS_f) and factor wage distortion variable ($WFDIST_{fa}$) are fixed and exogenous, while quantity of demanded of each factor from activities (QF_{fa}) and Factor price (WF_f) are flexible.

5.6 Elasticities and Calibration

Calibration of the model and simulation will be carried out in the GAMS (General Algebraic Modelling System) software, which is a direct descendant and development of models devised in the late 1980s and early 1990s, for example, those models reported by Robinson *et al.*, (1990), Kilkenny (1991) and Devarajan *et al.*, (1994). The calibration process involved the utilization of the SAM information for the purpose of estimating certain parameters of the model. The calibration of parameter relies on the specification of a number of elasticity values relating to the production, trade and household consumption processes to generate parameters automatically in GAMS modelling. Arndt *et al.* (2002) believe that the simulation results of CGE model are more sensitive to these elasticities. However, the values of elasticities used in the CGE-ILA model of UK cannot be obtained by using calibration techniques. Therefore, it is important to select the appropriate values from outside empirical sources. This process contains an extensive review of the existing literature.

Table 5.3 shows eight different elasticities from different countries' CGE model. The value of elasticities for CGE-ILA model are chosen from these existing date. There are three main elasticity blocks for CGE-ILA model, namely, production block, trade block and home consumption block. There are six substitution elasticities in the production block, one for output aggregation, one for substitution between aggregated factors and intermediate inputs, and the other four for substitution between production factors. Output aggregation elasticity (σ^a) is used to calculate the domestic aggregate marketed production of commodity of each industry. As show in Table 5.3, the value of it is set by Pouliakas *et al.* (2008) at 6 for Scotland, Greece and Latvia, by Lofgren *et al.* (2002) at 4 for Swaziland and Zimbabwe, and by Hyyia (2010) at 6 for Finland. Therefore, the value of output aggregation elasticity is chosen to be 6 for the UK, because the situation of the UK is close to Scotland and Finland.

The elasticity of substitution between aggregated factors and intermediate inputs (σ^d) is used in the first level CES nest production function. The higher the value of this elasticity, the larger the optimal change in the ratios between the quantities of value-added and the intermediate input aggregate in response to changes in their relative prices. Table 6.3 shows that this elasticity is set at the range from 0.1 to 1.5 for different countries. Considering the existing studies for the UK, Scotland and Finland, this value is chosen at 0.3 for this study (see Allan *et al.* 2007, Pouliakas *et al.* 2008 and Hyyia 2010).

One of the most distinct features of CGE-ILA model is that there are five primary factors, capital and four different skill types of labour. Differing from existing literatures, which set equal substitution between factors at one elasticity, this study presume different substitution between factors by using CES nest production functions. There are quite a lot of studies proved that the elasticity of substitution between labour and capital is less than 1, for example, Klump *et al.* (2004) found it between 0.5 and 0.7 for the US, Bolt and van Ells (2000) found thirteen developed countries lower than 1, Ripatti and Vilmunen (2001) got 0.6 for Finland, and McAdam and Willman (2004) found it between 0.7 and 1.2 for Germany. The elasticities of substitution between capital and aggregate labour (σ^{ya}) in different industries are set at the range from 0.3 to 1.2, as shown in the Table 6.4. The industry of Energy and Water Supply is the only one that the elasticity is larger than 1.

The empirical literature on substitution among types of labour and between them and capital can trace back to 1970s. Hamermesh and Grant (1979) reviewed 20 estimates of elasticities of substitution between blue collar and white collar workers and got the mean estimate at 2.3. Freeman (1982) found that elasticities of substitution between more and less educated labour range from 1.0 to 2.0. Johnson (1997) reported the substitution elasticity between unskilled labour and skilled labour at 1.5. This is similar to the results of 1.67 by Krusell *et al.* (2000). The selection of elasticity obeys the

assumption that the higher level of technology required industry, the harder for substitution among types of labour and the smaller value of elasticity. In this study, UK labour is divided into four skilled levels from highly-skilled to unskilled. Therefore, the skilled gaps between the highly-skilled and the skilled and between the semi-skilled and the unskilled are smaller than the gap between the aggregate higher-skilled and the aggregate lower-skilled. The elasticities of substitution of them are shown in Table 5.4 that the elasticities of substitution between higher-skilled and lower-skilled labour (σ^{lab}) range from 0.6 – 1.3, while the elasticities of substitution between highly-skilled and skilled labour (σ^{sk}) are set at around 1.5, and the elasticities of substitution between semi-skilled and unskilled labour (σ^{lusk}) are from 0.7 – 1.9.

The trade block contains two elasticities, Armington and CET elasticity. Following the approach suggested by Armington (1969), Armington elasticities (σ^q) which represent the elasticities of substitution among imports and competing domestic production play an important role in CGE. According to the Table 5.3, the range of Armington elasticities vary from 0.1 to 5. Welsch (2007) found that Armington elasticity for UK Agriculture industry at 1.4, and Manufacturing industry at 1.3. There are lots of studies focus Armington elasticities on Manufacturing industry, but very few on other industries. Thus, Armington elasticities for other industries in the UK are chosen at 2 (see Lisenkova *et al.* 2007, Hyyia 2010 and Pouliakas *et al.* 2008).

Domestic production from all activities is allocated between the domestic and the foreign markets, and the assumption of imperfect transformability between domestically sold goods and exports is governed by a constant elasticity of transformation (CET) function. Profit maximization drives producers to sell in those markets where they can achieve the highest returns. The values of CET elasticities (σ^t) for UK industries are assumed at 2 (see Lisenkova *et al.* 2007, Hyyia 2010 and Pauw 2002).

Household consumption elasticities contain Frisch parameter, expenditure elasticity of

home commodity demand by households, and expenditure elasticity of market commodity demand by households. Frisch parameter for household Linear Expenditure System (LES) demand is set to -1, which means the UK has the better-off part of the population. The CGE-ILA model assumes that there is no home-made commodity, so the elasticity of home commodity demand by households is set at 0. The values of expenditure elasticities of market demand for different commodities by households (γ^m) adopt the set for Finland by Hyyia (2010), which range from 0.4 – 1.3, as shown on Table 5.4. As all these elasticities are selected from outside sources, sensitivity analysis will be conducted to test the robustness of the findings to the assumed elasticity values.

Table 5.3 Elasticities for different countries' CGE models

	Countries	σ^{ac}	σ^a	σ^{va}	σ^q	σ^t	Frisch	γ^h	γ^m
Ahmed & O'Donoghue (2010)	Pakistan	4	0.6	0.5 - 1.5	2.0 - 4.0	2.0 - 4.0	-2		
Allan et al. (2007)	UK		0.3	0.3	2, 5	2, 5			
Barnes et al., (2008)	UK			0.4					
Bednarikov & Doucha(2009)	Czech	1.3	0.73	0.93	2	1.6	-1	1	1
Lisenkova et al., (2007)	Scotland			0.3	2	2			
Lofgren et al. (2002)	Swaziland	4	0.8	0.8	1.5	1.5	-2		1
	Zimbabwe	4	0.6	0.5 - 1.3	0.5 - 3	0.5 - 2	-2		0.68 - 1.50
Hyyia (2010)	Finland	6	0.1	0.3 - 1.2	2	2	-1		0.4 - 1.3
Pauw (2002)	South Africa	4	0.5	0.75	2	2			
Pouliakas et al. (2008)	Scotland	6	0.6	0.4	2	1.6	-1	1	0.3 - 1.3
	Greece	6	0.5 - 1.5	0.5 - 1.5	0.1 - 1.2	0.2 - 2.4	-1	1	0.4 - 1.0
	Latvia	6	0.6	0.8	0.8	1.6	-1	1	0.6 - 1.5
Zhao & Wang (2008)	China		0.1	0.3 - 2.5	1.3 - 3	2.8 - 4.6	-4		
Range		1.3 - 6	0.1 - 1.5	0.3 - 2.5	0.1 - 5.0	0.2 - 5.0		1	0.3 - 1.5

1. Source: Compiled by the author from different sources.

2. Notes:
- σ^{ac} output aggregation elasticity;
 - σ^a elasticity of substitution between aggregate factor and intermediate;
 - σ^{va} elasticity of substitution between factors;
 - σ^q Armington elasticity;
 - σ^t CET elasticity;
 - Frisch Frisch parameter for household LES demand;
 - γ^h expenditure elasticity of home commodity demand by household;
 - γ^m expenditure elasticity of market commodity demand by household.

Table 5.4 Selected Elasticities of different industries in CGE-ILA model

Industry	σ^{va}	σ^{lab}	σ^{lsk}	σ^{lusk}	σ^q	σ^t	γ^m
Agriculture	0.5	1.3	1.2	1.7	1.4	2	0.4
Energy and Water supply	1.2	0.6	1.3	1.7	2	2	1.1
Manufacturing	0.4	1.1	1.3	1.9	1.3	2	1.2
Construction	0.7	1.1	1.2	1.9	2	2	1.2
Distribution and Hotel	0.6	1.1	1.1	0.7	2	2	1.3
Transport and Communication	0.3	1.1	1.5	1.5	2	2	1.2
Finance and Business Services	0.6	0.7	1.5	0.6	2	2	1.2
Public Admin. and Education	0.8	0.9	1.6	0.9	2	2	1.2
other service	0.8	0.9	1.7	0.9	2	2	1.3
Range	0.3 – 1.2	0.6 – 1.3	1.1 – 1.7	0.7 – 1.9	1.3 - 2	2	0.4 – 1.3

1. Source: Chirinko *et al.* (2004), Hyyia (2010), Lisenkova *et al.* (2007), Pauw (2002), Pouliakas *et al.* (2008) and author calculation

2. Notes:
- σ^{va} elasticity of substitution between aggregate labour and capital;
 - σ^{lab} elasticity of substitution between aggregate higher-skilled and aggregate lower-skilled labour;
 - σ^{lsk} elasticity of substitution between highly-skilled and skilled labour;
 - σ^{lusk} elasticity of substitution between semi-skilled and unskilled labour;
 - σ^q Armington elasticity;
 - σ^t CET elasticity;
 - γ^m expenditure elasticity of market commodity demand by household.

5.7 Summary

The objective of this chapter is to develop a nine sectors, four types of labour, five income level household and three regions Computable General Equilibrium model (CGE-ILA) for assessing and comparing the quantitative economic impacts of increasing labour supply by international immigration on UK economy. This chapter described the behavioural and transaction relationships among UK economic agents, then use mathematical non-linear equations to state these relationships. The closure rules of CGE-ILA model are set as saving-driven, fixed foreign saving, fixed direct tax rates and fixed labour supply for UK economy. The values of elasticity parameters are chosen from the existing literature and will do sensitivity analyses to test the robustness at the end of simulation.

The CGE-ILA model developed in this study is an appropriate and useful tool that can provide some comprehensive insights. In order to enhance and broaden the analysis, the model used here has four distinct extensions from the standard IFPRI CGE model. Firstly, the labour is disaggregated into four different skill types to estimate the different impacts. A series of nested Constant Elasticity of Substitution (CES) production functions are used to present the relationships among these different skill types of labour. Secondly, the households have been divided in to five income levels in order to provide a deeper insight into some of the consequences of labour immigration. Thirdly, in order to learn the effects of European integration, the EU zone is separated from the rest of world. Fourthly, the labour markets are modelled as imperfect to consider the effects on unemployment. These additional features enrich the analysis of the economic impacts of international labour immigration on the UK.

The model is calibrated in GAMS (General Algebraic Modelling System) programme to the purpose-built UK SAM database for the year 2004, which is presented in the Chapter Six. The model files are documented in the appendix 2, which is available in electronic form from the author upon request.

Chapter Six:

Social Accounting Matrix for UK 2004

6.1 Introduction

A Social Accounting Matrix (SAM) is an excellent descriptive tool, showing in detail the structure of an existing national economy (Pradhan *et al.*, 2006). It provides important information on interaction among domestic industries, production factors, households' behaviour, government behaviour and a link with the foreign world. This chapter will describe the augmented SAM for UK 2004 to which the CGE-ILA model for the UK in Chapter Five is calibrated.

Since the model is applied to the United Kingdom, features that are unique to the UK and especially its labour market are emphasised. The SAM is predominantly compiled from the United Kingdom Input-Output Supply and Use Tables (SUT) for the year 2004⁴, supplemented with data from UK National Account Blue Book 2006 edition, International Labour Organisation (ILO) for UK 2004 and the Annual Survey of Hours and Earnings for the year 2004 (ASHE). The structure of production, output, demand and trade are taken from the SUT data source, which provides a commodity-by-industry use matrix for 123 commodities and industries. A commodity-by-industry make matrix is derived from data on industry and commodity output in 2004. The data source employs the disaggregation of labour and household data from the ILO and ASHE. The UK National Accounts Blue Book is used to ensure that household aggregates are correct.

Section 6.2 builds up an aggregated SAM database for the UK. Section 6.3 provides a descriptive analysis of the UK economy, including sector aggregation, factor

⁴Office for National Statistics (ONS, 2006).

specification, and households division by presenting the data in tables. Section 6.4 analyses the characteristics of UK economy by using SAM. The last section concludes.

6.2 Construction of Aggregated UK SAM 2004

The basic SAM structure has been presented in the section 4.3 above. For the construction of the UK SAM, data from UK Input-Output SUT tables 2004 has been mainly transferred to create ‘Activities’ and ‘Commodities’ accounts. The supply table provides information of UK domestic commodities supply, including total domestic output, total imports of goods and services, and taxes less subsidies on import products. The demand table is divided into intermediate consumption and final consumption. The intermediate consumption table provides data for domestic production activities, including industries’ intermediate input and gross value added (the sum of compensation of employees, gross operating surplus and taxes less subsidies on production). On the other hand, the final demand table shows the amount of household and government consumption, as well as gross capital formation (investment and stock change) and total exports of products.

The rest required data in the UK SAM are extracted from UK Blue Book for 2006 edition, in which UK summary accounts 2004 provide the data of allocation of primary income, secondary distribution of income and saving for domestic institutions and rest of world.

At the end, according to the structure of SAM presented in Figure 4.1 of Chapter Four, Table 6.1 builds up a real world aggregated SAM for the UK 2004. The data in Table 6.1 are presented in million British pounds, which are largely calculated from UK Input-Output SUT tables 2004 and National Bluebook 2006.

Table 6.1 Aggregated SAM for UK 2004

		1	2	3	4	5	6	7	8	
		Activities	Commodities	Factors	Households	Enterprise	Govt.	S-I	ROW	Total
1	Activities		2151831							2151831
2	Commodities	1107666			761484		250708	199309	298696	2617863
3	Factors	1027311							1100	1028411
4	Households			715319		77380	139245		9407	941351
5	Enterprise			261444						261444
6	Govt.	16854	132363	50477	146529	34301			142	380666
7	S-I				33338	149763	-9287		25495	199309
8	ROW		333669	1171						334840
	Total	2151831	2617863	1028411	941351	261444	380666	199309	334840	

Source: Author calculate

Note: data are presented in million British pounds

6.3 Disaggregation of UK SAM 2004

For the purposes of this research, the aggregated SAM in Table 6.1 will be tailored to a specific model, which requires some adjustment and disaggregation to fit the CGE-ILA framework constructed in the former chapter. The following steps will describe the detail of disaggregation.

6.3.1 Sectors

The activity/commodity structure of the CGE model is an aggregation of the 123 industries which are classified by Standard Industrial Classification in the SUT (Table 6.2).

Table 6.2 Sectors Aggregation in the CGE model

No.	Sectors	Description	Correspondence 123 Industry Level
1	Agriculture	Agriculture, forestry & fishing	1, 2, 3
2	Mining & Energy	Mining, energy and water supply	4,...,7, 85, 86, 87
3	Manufacturing	Manufacturing	8,...,84
4	Construction	Construction	88
5	Distribution & Hotels	Distribution, hotels and restaurants	89,...,92
6	Transport & Communication	Transport and communication	93,...,99
7	Finance & Business Services	Finance and business services	100,...,114
8	Public Administration & Education	Public administration, education and health	115,...,118
9	Other Services	Other services	119,...,123

Source: SUT 2006

123 industries are divided into nine main sectors as Table 6.2 shows. Sector 1 and 2 are the Primary Industries which provide natural things. Sector 3 and 4 are Secondary

Industries which make, build and assemble tangible products. Sector 5, 6, 7, 8, and 9 are Tertiary Industries which give value to people but are not physical goods. The service industries are also particularly important in modern Britain that employs more than 75 percent of labour in the UK. It is undoubted that the immigration labours would join into the Tertiary industries.

6.3.2 Labour Specification

The model distinguishes two production factors, capital (mainly land, buildings and equipment) and labour. Firstly, the data of capital can be obtained directly from UK SUT table, which will not be disaggregated in model. Secondly, the aggregate labour using common job classifications method is divided into nine major labour types as the Table 6.3 shown below. Job classification approaches rely on the International Labour Organization's *International Standard Classification of Occupations* (ISCO-88). For the purpose of CGE-ILA analysis, Winchester et al (2006) cluster analysis is obtained to identify four distinct types of labour, namely, high-skilled, skilled, semi-skilled and unskilled, which measures skills by occupational groups, hourly wages and weekly working hours by occupations.

Table 6.3 International Standard Classification of Occupations (ISCO-88)

ISCO code	Occupation	ISCO code	Occupation
1	Legislators, senior officials and managers	6	Personal service occupations
11	Legislators and senior officials	61	Market-oriented skilled agricultural and fishery workers
12	Corporate managers	62	Subsistence agricultural and fishery workers
13	General managers	7	Sales and customer service occupations
2	Professional occupations	71	Extraction and building trade workers
21	Physical, mathematical and engineering science professionals	72	Metal, machinery and related trades workers
22	Life science and health professional	73	Precision, handicraft, printing and related trades workers
23	Teaching professionals	74	Other craft and related trades workers
24	Other professionals	8	Process, plant and machine operatives
3	Associate professional and technical occupations	81	Stationary plant and related operators
31	Physical and engineering science associate professionals	82	Machine operators and assemblers
32	Life science and health associate professionals	83	Drivers and mobile plant operators
33	Teaching associate professionals	9	Elementary occupations
34	Other associate professionals	91	Sales and services elementary occupations
4	Administrative and secretarial occupation	92	Agricultural, fishery and related labourers
41	Office clerks	93	Labourers in mining, construction, manufacturing and transport
42	Customer service clerks		
5	Skilled trades occupations		
51	Personal and protective services workers		
52	Models, salespersons and demonstrators		

Source: laborsta.ilo.org

Table 6.4 Classification of labour types in the CGE-ILA model

Type	ISOC Code	Description	Average hourly pay GBP£*	Weekly working Hours
Highly-skilled	1	Legislators, senior officials and managers	18.60	45.65
	2	Professional occupations		
Skilled	3	Associate professional and technical occupations	11.22	40.50
	4	Administrative and secretarial occupation		
Semi-skilled	5	Skilled trades occupations	8.61	42.03
	6	Personal service occupations		
Unskilled	7	Sales and customer service occupations	7.51	42.65
	8	Process, plant and machine operatives		
	9	Elementary occupations		

Source: Annual Survey of Hours and Earnings 2004, ONS

*: GBP£ will be abbreviated by £ here after.

Table 6.4 describes four regrouped labour types by using Winchester et al (2006) cluster analysis, namely, L1 highly-skilled, L2 skilled, L3 semi-skilled, and L4 unskilled. The hourly pay for highly-skilled labour is more than two times than unskilled labour. Although the highly-skilled labour has the highest hourly pay at £18.60, they are working the longest time for 45.65 hours per week. The immigration labours would follow these types of labour to analyse their different economic impacts on the UK.

Table 6.5 presents a detailed economic active population by sectors and labour types for UK 2004. The total amount of active population is about 27.9 million, which has been divided into 7.6 million for highly skilled labour, 7.3 million for skilled labour, 7.7 million for semi-skilled labour and 5.3 million for unskilled labour. Highly-skilled labours are mostly focused on service industries, especially sector 7 (Finance and Business Services) and sector 8 (Public administration and Education) have 1.7 million and 2.4 million, separately. The majority of skilled labours which are similar with highly-skilled labours work in sector 7 and 8 as well. Sector 5 (Distribution and Hotel)

employs the most semi-skilled labour at 2.8 million; and the following is sector 8 which has 2.2 million. There are more than 3 million unskilled labours employed in manufacturing and construction industries, which takes about 60 percent of total unskilled labours. Although labour in primary industries only takes up 2.23 percent in total labour market, the labour makeup in sector 1 (agriculture) and sector 2 (energy and water) are significant different. Agriculture sector employed about 2 million unskilled labours which are much more than other labour types. On the contrary, energy and water sector employed more high-skilled and skilled labour, which took 33% and 26% in total.

The Table 6.6 shows the gross labour income by sectors and labour types for UK 2004. There is about 46 percent of labour income is made by high-skilled labours which only take 27 percent of total labours. Sector 7 (Finance and Business Service) provided highly-skilled labour with the highest income for 92.7 billion pounds, followed by sector 8 for 83.2 billion pounds. Skilled labour gained the highest income from sector 8, semi-skilled labour from sector 5 and unskilled labour from sector 3. Agriculture is the least skill intensive in its use of labour (highly-skilled and skilled labours generating only 25% of gross labour income). Whereas, at the other end of the spectrum, finance is relatively the most skill intensive (highly-skilled and skilled labours generating about 91% of gross labour income in that sector). In a world, higher-skilled labours mostly concentrate in the Tertiary Industries in the UK.

Table 6.5 Economic active population by sectors and labour types, UK 2004 (thousand)

Sector	Highly-skilled		Skilled		Semi-skilled		Unskilled		Total	
	,000	%	,000	%	,000	%	,000	%	,000	%
1 Agriculture	37.80	10.61	23.73	6.66	96.31	27.04	198.33	55.68	356.17	1.28
2 Energy and Water	87.98	33.13	68.93	25.96	38.86	14.63	69.79	26.28	265.57	0.95
3 Manufacturing	947.58	25.11	736.91	19.53	421.85	11.18	1666.70	44.17	3773.03	13.54
4 Construction	389.74	17.04	290.72	12.71	239.88	10.49	1366.40	59.75	2286.73	8.21
5 Distribution and Hotel	1236.00	22.19	691.33	12.41	2845.21	51.09	796.87	14.31	5569.41	19.99
6 Transport and Communication	332.60	17.49	337.55	17.75	569.76	29.96	661.88	34.8	1901.79	6.83
7 Finance and Business Services	1748.85	40.32	1764.34	40.68	667.26	15.38	157.10	3.62	4337.55	15.57
8 Public administration and Education	2431.46	31.7	2855.40	37.23	2184.50	28.48	198.25	2.58	7669.61	27.53
9 Other services	340.22	20.04	533.82	31.45	672.18	39.6	151.31	8.91	1697.53	6.09
Total	7552.22	27.11	7302.72	26.21	7735.80	27.77	5266.63	18.91	27857.37	100.00

Source: ILO

Table 6.6 Gross labour income by sectors and labour types, UK 2004 (million £)

Sector	Highly-skilled		Skilled		Semi-skilled		Unskilled		Total	
	million £	%	million £	%	million £	%	million £	%	million £	%
1 Agriculture	612	17.79	271	7.89	1012	29.43	1543	44.89	3438	0.53
2 Energy and Water	3762	48.42	1856	23.89	853	10.98	1299	16.71	7770	1.2
3 Manufacturing	41965	40.11	22185	21.21	10445	9.98	30022	28.70	104617	16.13
4 Construction	8639	27.59	4668	14.91	3674	11.74	14326	45.76	31307	4.83
5 Distribution and Hotel	38378	37.50	14134	13.81	40769	39.83	9064	8.86	102346	15.78
6 Transport and Communication	16168	29.84	11267	20.80	14475	26.72	12264	22.64	54173	8.35
7 Finance and Business Services	92700	64.51	38563	26.84	10235	7.12	2205	1.53	143703	22.15
8 Public administration and Education	83152	49.82	54301	32.53	27285	16.35	2180	1.31	166918	25.73
9 Other services	12713	36.91	11667	33.87	8531	24.77	1534	4.45	34445	5.31
Total	298089	45.95	158913	24.50	117277	18.08	74437	11.47	648717	100

Source: SUT 2004 and author calculation

6.3.3 Households Division

According to the average monthly income, households (HH) in Expenditure and Food Survey UK 2004 are evenly divided into 10 deciles from the lowest income to the highest income. Due to the data limitation, households are aggregated into five quintiles as show in Table 6.7. This table exploits various socio-economic characteristics of household. Firstly, of the 24.67 million households, the average household size is 2.36 and the average monthly household income is £2533. Secondly, the first quintile (HH1) which is the lowest income household (£833 per month) has the smallest family size at 1.45 and the fifth quintile (HH5) which is the highest income household (£5304 per month) has the largest family size at 3.1. Thirdly, the economic status among these households is varying dramatically. There are only 11 percent of first quintile household are working members, which size is 0.16. On the contrary, the fifth quintile household has 85 percent of family members have jobs, which size is 2.65.

Table 6.7 The Division of Household (HH) in the UK: 2004

	All HH	HH1	HH2	HH3	HH4	HH5
No. of HH (,000)	24,670	4,940	4,930	4,940	4,930	4,930
Size of HH	2.36	1.45	2	2.45	2.8	3.1
Ave Monthly Income (£)	2533	833	1362	2156	3008	5304
% of Working force	61	11	38	62	77	85
% of Non-working force	39	89	62	38	23	15

Source: ILO

Notes: HH1, HH2...and HH5 represent First quintile, Second quintile... and Fifth quintile households

The division of households defines the various types of individual in the model. Each income level of household has different types of labours, in line with the classification of labour. Table 6.8 displays the labour composition of households in the UK 2004. It is clearly showing that the lower income household groups (first and second quintiles) contain more lower-skilled labours, but the higher income household groups (fourth and fifth quintiles) contain more higher-skilled labours.

Table 6.8 The labour composition of households in the UK: 2004

Labour type	HH1 %	HH2 %	HH3 %	HH4 %	HH5 %	All HH %
Highly-skilled	5	10	16	27	40	27.1
Skilled	5	13	24	27	32	26.2
Semi-skilled	40	37	35	28	20	27.8
Unskilled	50	40	25	18	8	18.9
Total	100	100	100	100	100	100

Source: adapted from Expenditure and Food Survey 2004

- **Households income by source**

Gross labour income by skill type is distributed over households by skill and household type using data from UK SUT 2006 and ILO 2004. In the same way, gross capital income from the SUT is assigned to households according to the distribution of income from other payments in the National Accounts Bluebook, such as rent from property or subletting, educational grants, regular payments from friends and family outside the household. Table 6.9 displays the disaggregated data of factor income by household types. Highly-skilled labour gives mostly income to all households (41% of total gross factor income). The fifth quintile household receive 53% income from the highly-skilled labour. However, the first quintile household income depend 44% on unskilled labour. In total factor income for households, the income increased from the lowest at 1 percent for the first quintile household to approximately 42 percent for the fifth quintile.

Total disposable household income (Table 6.10) is the result of adjusting the gross earnings data for income and taxes, and adding income transfers from enterprise (pensions), government (benefits), the rest of Europe (ROE) and the rest of world except Europe (ROW) remittances. The total value of income taxes is obtained from the National Accounts Bluebook 2006 for household income tax. The tax rate for lower income households is smaller than the higher income households. Income transferred from enterprise, government, ROE and ROW to household, data are also from the National Account Bluebook 2006, are disaggregated using the distribution

of household income by source in the ILO 2004.

Table 6.10 shows that the lowest income households (the first quintile) rely relatively heavily from enterprise and government transfers as a source of disposable income at about 87 percent. In contrast, the incomes of the fifth quintile households, which have the highest income, mainly rely on the work at about 93 percent. The lower income households would gain more government benefits. Transfers from both ROE and ROW are quite small, and mainly from ROE. The total disposable income for the fifth quintile households is about three times more than the total disposable income for the first quintile households.

- **Household expenditure by destination**

Households allocate income over consumption and savings. The total household saving is obtained from the National Accounts Bluebook 2006. The lower income households which mainly rely on enterprise and government's transfers have very little saving money that is approximately infinite close to zero. Table 6.11 displays household expenditure on commodities and savings by type of household for UK 2004. The household saving rate of disposal household income in Table 6.11 is 4.19% which is much lower than the national saving rate of 15.6%. The table also reveals that that mass of household expenditure on goods are focused on manufacturing, finance and business services, distribution and hotel, and other services, respectively, 42.7%, 19.6%, 13.5% and 6.9% of private consumption expenditures.

Table 6.9 Gross factor income by household types, UK 2004

Household	Highly-skilled		Skilled		Semi-skilled		Unskilled		Capital		Total	
	million £	%	million £	%	million £	%	million £	%	million £	%	million £	%
HH1	1215	12.2	669	6.7	3714	37.3	4356	43.8			9954	1.4
HH2	11547	19.4	8260	13.9	16319	27.4	16552	27.8	6869	11.5	59547	8.3
HH3	36950	28.1	30498	23.2	30874	23.5	20691	15.8	12288	9.4	131300	18.4
HH4	87295	41.8	48576	23.2	35600	17.0	21287	10.2	16284	7.8	209042	29.2
HH5	161049	52.7	70894	23.2	30758	10.1	11543	3.8	31232	10.2	305476	42.7
Total	298056	41.7	158896	22.2	117265	16.4	74429	10.4	66673	9.3	715319	100

Source: adapted from SUT 2004, ILO 2004.

Table 6.10 Disposable income by type of household, UK 2004

Household	Factor		Enterprise		Government		ROE		ROW		Total	
	million £	%	million £	%	million £	%	million £	%	million £	%	million £	%
HH1	8 602	12.9	11316	17.0	46475	69.8	126	0.19	19	0.03	66 538	8.4
HH2	49 748	44.0	23142	20.4	39537	34.9	666	0.59	98	0.09	113 191	14.2
HH3	105 525	66.3	22191	13.9	29642	18.6	1503	0.94	222	0.14	159 083	20.0
HH4	167 102	83.5	13716	6.9	16541	8.3	2436	1.22	360	0.18	200 155	25.2
HH5	237 813	92.9	7015	2.7	7050	2.8	3465	1.35	512	0.20	255 855	32.2
Total	568 790	71.6	77380	9.7	139245	17.5	8196	1.03	1211	0.15	794 822	100

Source: adapted from Bluebook 2005, ILO 2004.

No matter higher or lower income households, they spend the similar amount of income for necessary survival goods from Agriculture (C1) and Energy and Water (C2). For goods and service from other industries, the higher income households usually have a larger consumption than the lower income households. The most significant difference is the consumption of Public Administration and Education (C8) that the higher income households (HH5) expend almost ten times more than the lower income households (HH1).

Table 6.11 Household expenditures by type of household, UK 2004

Household expenditures (million £)	HH1	HH2	HH3	HH4	HH5	Total	%
C1 Agriculture	2234	2580	2661	2653	2296	12423	1.6
C2 Energy and Water	3643	3800	3719	3745	3845	18753	2.5
C3 Manufacturing	28436	51115	62996	80640	101858	325044	42.7
C4 Construction	486	907	1280	1636	1804	6112	0.8
C5 Distribution and Hotel	14568	17012	24449	26848	19789	102666	13.5
C6 Transport and Communication	2857	5729	8581	11882	16332	45381	6.0
C7 Finance and Business Services	8167	18914	30309	39016	52969	149376	19.6
C8 Public administration and Education	2198	5478	7978	10452	22778	48885	6.4
C9 Other services	3947	7658	10443	13282	17515	52844	6.9
Total consumption	66538	113191	152415	190154	239186	761484	100
Savings			6668	10001	16669	33338	
Savings rate (%)			4.19	5.00	6.52	4.19	
Disposable income	66538	113191	159083	200155	255855	794822	

Source: adapted from SUT 2006, ILO 2004

6.4 Characteristics of UK Economy for 2004

Using the data collected from the UK SUT 2006, UK National Account Bluebook 2006, ILO 2004 and ASHE 2004, it can now consider some significant features of UK economy as represented in the SAM. The GAMS (General Algebraic Modelling System) software is used to analyse the UK baseline year 2004. Initially, the economic structure of the UK is concerned, followed by an examination of pattern with regard to GAMS

results. Then the factors demands in different sectors are presented.

6.4.1 Economic Structure

Table 6.12 reports that the UK GDP at market price, which from spending approach includes private consumption, fixed investment, stock change, government consumption, exports and imports, is 1189.47 billion pounds in 2004. Private consumption is the most important component of UK GDP that takes up to 65.7% of GDP, followed by government consumption 21.2% and fixed investment 16%. The data shows that the UK is a net import country that total import is about 40.4 billion pounds more than total exports. Furthermore, as a key member of EU, the UK imports 192.7 billion pounds from EU which is 36.8 billion pounds more than imports from other countries. Similarly, the UK exports more to EU than to other countries at about 7.8 billion pounds. Calculating GDP from the value-added approach shows that 86.8% of GDP are contributed by factors and the rest is from net indirect taxes.

Table 6.12 Aggregate National Accounts Summary (billion pounds)

	VALUE	PERC-GDP
ABSORP	1229.82	103.39
PRVCON	781.92	65.74
FIXINV	190.59	16.02
DSTOCK	5.02	0.42
GOVCON	252.29	21.21
EXPORTS	150.19	12.63
EEXPORTS	158.02	13.28
IMPORTS	-155.86	-13.10
EIMPORTS	-192.69	-16.20
GDPMP	1189.47	100.00
NETITAX	156.49	13.16
GDPFC2	1032.98	86.84

*ABSORP: absorption; PRVCON: private consumption; FIXINV: fix investment; DSTOCK: stock change, GOVCON: government consumption, EXPORTS: exports to non-EU; EEXPORTS: exports to EU; IMPORTS: imports from non-EU; EIMPORTS: imports from EU; GDPMP: GDP at market price; NETITAX: net indirect taxes; GDPFC2: GDP at factor cost.

Table 6.13 describes economic structure of the UK in the baseline year 2004. It can be seen clearly that UK is a non-agricultural country that agriculture sector (C1) only contributed about 1% in value-added share and slightly more than 1% in total production share of total economy in 2004. On the other hand, the Tertiary Industries (C5 – C9) made the contribution more than 73% to value-added and about 67.1% to total domestic production. Moreover, the Tertiary Industries employed more than three quarters of total employment. These all prove that as a developed country for such a long period, the Tertiary Industries are well developed as the pillar industries in UK economy. In particular, industries of Finance and Business Services (C7) contributed the largest proportion for both value-added at nearly 30% and production at 27.5%, followed by Public administration and Education (C8) at 19.3% and 16%, separately.

Table 6.13 shows that the major trading products are from Manufacturing Industries (C3) that take up more than 52% of total exports and 77% of total imports. The secondary important export products for UK are from Finance and Business Services (C7), which occupy more than a quarter of total exports. Although only 2% of total imports are Agriculture (C1) goods, these are approximately a quarter of domestic agriculture commodities demand.

This study divides UK trading partners into two main objectives, EU (ROE) and rest of world except EU (ROW). The results in Table 7.14 also show that UK has more correlation with other EU members than other countries. The UK exports more tangible products to other EU countries, such as C1, C2 and C3. However, it exports more intangible products to other countries, which mainly from the Tertiary Industries. On the same way, UK usually imports more products from EU countries. There is only one special product, Energy and Water Supply (C2), that the imports from rest of world except EU are eleven times more than from other EU countries at 17.3% and 1.5% of domestic demand, separately.

Table 6.13 UK Economic Structure in the Baseline Year 2004 (%)

Commodities of Industry	VAshr	PRDshr	EMPshr	EXPshr	EEXPshr	EXP- OUTshr	EEXP- OUTshr	IMPshr	EIMPshr	IMP- DEMshr	EIMP- DEMshr
C1	1.07	1.09	1.18	0.17	0.42	2.30	5.62	0.89	1.09	10.94	13.56
C2	3.74	3.90	0.92	1.92	3.31	7.17	12.34	4.02	0.34	17.31	1.47
C3	15.53	19.66	12.89	21.96	30.47	16.27	22.58	32.32	45.09	21.81	29.87
C4	6.69	8.29	8.33	0.11	0.06	0.20	0.11	0.05	0.04	0.14	0.07
C5	11.36	11.20	19.71	3.44	2.39	4.48	3.11	0.77	1.14	1.21	1.76
C6	7.52	7.87	6.66	3.91	3.15	7.24	5.83	1.60	3.19	3.49	6.89
C7	29.81	27.50	17.20	14.91	10.26	7.90	5.44	3.80	3.15	2.53	2.08
C8	19.25	16.03	27.43	0.66	0.46	0.60	0.42	0.27	0.36	0.29	0.37
C9	5.02	4.46	5.67	1.64	0.74	5.36	2.43	0.99	0.88	3.78	3.27
TOTAL-1	100	100	100	48.73	51.27	7.10	7.47	44.71	55.29	7.34	8.93
TAGR	1.07	1.09	1.18	0.17	0.42	2.30	5.62	0.89	1.09	10.94	13.56
TNAGR	98.93	98.91	98.82	48.56	50.85	7.15	7.49	43.82	54.19	7.30	8.87
TOTAL-2	100	100	100	48.73	51.27	7.10	7.47	44.71	55.29	7.34	8.93

*Industry C1: Agriculture; C2: Energy and Water supply; C3: Manufacturing; C4: Construction; C5: Distribution and Hotel; C6: Transport and Communication; C7: Finance and Business Services; C8: Public administration and Education; C9: other service.

** VAshr: value-added share (%); PRDshr: production share (%); EMPshr: share in total employment (%); EXPshr: sector share in total Non-EU exports (%);EEXPshr: sector share in total EU exports (%);EXP-OUTshr: Non-EU exports as share in sector output (%); EEXP-OUTshr: EU exports as share in sector output (%); IMPshr: sector share in total Non-EU imports (%); EIMPshr: sector share in total EU imports (%);IMP-DEMshr: Non-EU imports as share of domestic demand (%); EIMP-DEMshr: EU imports as share of domestic demand (%).

6.4.2 Factors in Sectors

According to the Table 6.14, factors input in the activities of sector are divided in to two main group, capital and labour (including highly-skilled labour, skilled labour, semi-skilled labour and unskilled labour). As can be seen in the CAP column, factor of capital plays a very important role in sectors of Energy and Water Supply (A2), Agriculture (A1), Construction (A4) and Finance and Business Services (A7), which are 78.6%, 66.1%, 51.0% and 50.5% in total factor demands, respectively. Thus, these sectors are capital-intensive. In total, capital represents a major part of the production process for 36.6% in UK industries.

Table 6.14 Factor Shares within Industries (%)

Activities of industry	L1	L2	L3	L4	CAP	TOTAL
A1	6.25	3.13	10.19	14.31	66.13	100
A2	10.17	5.09	2.55	3.55	78.64	100
A3	29.11	15.32	7.51	20.30	27.76	100
A4	13.63	7.38	6.05	21.94	51.00	100
A5	25.05	9.20	27.43	5.80	32.51	100
A6	20.74	14.40	19.16	15.35	30.35	100
A7	31.87	13.19	3.65	0.77	50.52	100
A8	43.04	27.95	14.59	1.14	13.28	100
A9	23.26	21.23	16.14	2.86	36.50	100
TOTAL	29.16	15.65	11.11	7.47	36.61	100

*Industry A1: Agriculture; A2: Energy and Water supply; A3: Manufacturing; A4: Construction; A5: Distribution and Hotel; A6: Transport and Communication; A7: Finance and Business Services; A8: Public Administration and Education; A9: other service.

** L1: Highly-skilled labour; L2: Skilled labour; L3: Semi-skilled labour; L4: Unskilled labour; CAP: Capital.

In labour part, highly-skilled labour (L1) usually plays the most important role for most industries, i.e., 43.0% for Public Administration and Education (A8), 32.0% for Finance and Business Services (A7) and 29.1% for Manufacturing (A3). Distribution and Hotel (A5) asks for the most semi-skilled labour (L3) at 27.4%, and unskilled labour (L4) is the most important labour input for Construction (A4) at 21.9% and Agriculture (A1) at 14.4%. To sum up, different industries ask for different factors input combinations.

Table 6.15 shows the average labour wages in different industries in UK 2004. It is undoubtedly that the higher-skilled of labour would have higher wage in the same industry. The highest average wage for the highly skilled labour (L1) is 53.6 thousand pounds per year in Finance and Business Services (A7), and the lowest average wage is supplied by Agriculture (A1) at 19.8 thousand pounds per year which is about one third of the highest. Industries of Manufacturing (A3) provide the highest annual average wages for skilled labour (L2), semi-skilled labour (L3) and unskilled labour (L4) at £34.95 thousand, £30.05 thousand and £20.61 thousand, separately. On the contrary, the lowest annual average wages for these three types of labour are gained from industries of Distribution and Hotel (A5).

Table 6.15 Average Labour Wages by Sector (£1,000)

Activities of industry	L1	L2	L3	L4
A1	19.78	15.79	12.72	8.70
A2	46.30	29.64	26.37	20.56
A3	51.56	34.95	30.05	20.61
A4	23.44	17.03	16.99	10.84
A5	23.42	15.40	11.20	8.48
A6	49.30	33.76	26.71	18.48
A7	53.58	22.01	16.18	14.43
A8	35.15	19.46	13.33	11.50
A9	38.08	22.18	13.44	10.61
TOTAL	39.76	22.10	14.87	14.71

6.5 Summary

The main purpose of this chapter is to build up a Social Accounting Matrix (SAM) which is suitable for use in a Computable General Equilibrium (CGE) model applied to the UK with different types of labour immigration. The whole country's industries are aggregated into nine main sectors in order to find out the effects of different labours. According to the skill level, labour is grouped into four types, highly-skilled, skilled,

semi-skilled and unskilled labour, to capture differences in UK economy. Households are aggregated into five types based on different income levels. The SAM is constructed mainly from the Supply and Use Tables (SUT) for UK 2006, and subsequently enriched with data from UK Blue Book 2005, International Labour Organisation (ILO) and Annual Survey of Hours and Earnings 2004 (ASHE). The detailed UK SAM 2004 database is presented in Appendix 3 and available in electronic form upon request.

The data of economic active population reveals that the UK has more number of higher-skilled labours than lower-skilled labours and most labours are concentrated in the Tertiary Industries. The household income data expose that the lower income households are mostly composited by lower-skilled labour and rely primarily on government benefits. On the contrary, the incomes of higher income households are mainly from working. The disposable income is mostly allocated to the consumption of goods and services, especially Manufacturing (C3), Finance and Business Services (C7) and Distribution and Hotel (C5). Only three higher income levels of households have the remaining part of disposable income for saving.

The characteristics of UK economy show that UK has more trading correlation within EU than with other world countries firstly. Secondly, as a well-developed country, the Tertiary Industries plays a pillar role in UK economy that employed the majority of labour and brought about the main value-added and production. Thirdly, capital remains the main input of production process and higher-skilled labour usually play more important roles in each industry. Fourthly, compared with the lowest average wage of highly-skilled labour in Agriculture (A1), the highly-skilled labour in Finance and Business Services (A7) has the highest average wage.

Chapter Seven:

Policy Simulation Results

7.1 Introduction

The UK is probably the country that has been the most favourite destination of labour immigration from the EEU and commonwealth countries' labour (Hatton, 2005). The past five or more decades' history has evidenced the immigration movement inflowing into the country. Thus, the overall impacts of international immigration on UK economy either positively or negatively have been played a critical role over the modern history. The globalisation occurred since the end of the last century has also magnified this trend and its effects. This chapter illustrates on policy scenarios conducted with a CGE-ILA model for the UK, which contains four-level nested CES production function and special imperfect labour market effects between three regions (the UK, the rest of EU and the rest of world). The CGE-ILA model is calibrated to the UK 2004 Social Accounting Matrix (SAM) with special detail in terms of labour supply and household income. The model is solved by using the GAMS (General Algebraic Modelling System) programme, which was initially developed by the World Bank.

The impacts of immigration on UK economy are conducted by simulations with different scenarios, which take the form of exogenous changes in UK labour supply. The scenarios can be divided into three main groups. The first group (Group A) estimates the effects on UK economy by different skill types of labour immigration and overall supply of labour, simulated as an increase in the supply of these categories of workers by small scale. The second group (Group B) assumes a large scale labour immigration to compare the different effects with the first group. The third group (Group C) tries to measure the effects of the decreasing immigration labour on UK

economy.

Table 7.1 Codes and Definitions of Immigration Scenarios

Scenario	Explanation
Base	Baseline Scenario (the current trend continues forward)
Group A	
A1	1% increase in the labour supply quantity of senior officials, managers and professions.
A2	1% increase in the labour supply quantity of technicians, associate professionals and clerks.
A3	1% increase in the labour supply quantity of service workers and elementary occupations.
A4	1% increase in the labour supply quantity of trade workers machine operators and assemblers.
A5	1% increase in the labour supply quantity of all types of labour.
Group B	
B1	10% increase in the labour supply quantity of senior officials, managers and professions.
B2	10% increase in the labour supply quantity of technicians, associate professionals and clerks.
B3	10% increase in the labour supply quantity of service workers and elementary occupations.
B4	10% increase in the labour supply quantity of trade workers machine operators and assemblers.
B5	10% increase in the labour supply quantity of all types of labour.
Group C	
C1	1% decrease in the labour supply quantity of senior officials, managers and professions.
C2	1% decrease in the labour supply quantity of technicians, associate professionals and clerks.
C3	1% decrease in the labour supply quantity of service workers and elementary occupations.
C4	1% decrease in the labour supply quantity of trade workers machine operators and assemblers.
C5	1% decrease in the labour supply quantity of all types of labour.

Table 7.1 gives an overview of the scenario codes and their explanation. (1) Scenario Base is the baseline simulation. (2) In Group A, the scenario A1 assumes the international labour immigration causes 1 percent increase in the labour supply of highly-skilled labours, which are qualified to be senior officials, managers and professions. Scenario A2 assumes that immigrants have the same qualification as UK skilled labour (technicians, associate professionals and clerks) and increase by 1 percent. Scenario A3 assumes immigrants are semi-skilled labour, which are doing service and

elementary jobs, and increase the UK semi-skilled labour supply by 1 percent. Scenario A4 assumes that the quantities of unskilled labour in the UK are expanded by international immigration at 1 percent. Scenario A5 is designed to investigate the effects of total labour supply increased by 1 percent, which equals to the sum of previous four scenarios. (3) The scenarios in Group B are similar with those in Group A, but assume a large scale labour immigration at 10 percent. (4) The scenarios in Group C assume the reduction of domestic labour supply caused by the decreasing number of immigration labour in different skill types. Results are compared with the benchmark-equilibrium values for UK 2004 on a number of important variables and presented in the form of percentage changes.

This chapter is structured as follows: section 7.2 presents the economic impacts of labour immigrations on UK macro-economic performance; section 7.3 presents the impacts on UK labour market; section 7.4 examines scenarios to show the impacts on UK households; and section 7.5 presents the impacts of labour immigration on industries, such as labour demand, production prices and quantities. Section 7.6 presents the sensitivity analysis of CGE-ILA model. Section 7.7 concludes.

7.2 Economic Impacts on Macro-Economic Performance

Immigration or free movement of labour forces is described as the process of optimal allocation of human resources, one of important production factors, in order to maximise the well being of the whole world. It is fair to say that most (if not all) immigration is for economic reasons, from the viewpoints of either immigrants or host countries. Thus, the impacts on macro-economic performance are first and for most important aspects. The simulation results in Table 7.2A and 7.2B indicate the percentage changes in the real macroeconomic magnitudes (namely the percentage deviations from the base values, that in turn are the 2004 figures applicable to the UK) in both small

scale (Group A scenarios) and large scale (Group B scenarios) labour immigration. A number of indicators have been employed to reflect impacts of labour immigration on UK macro-economic performance, they include the real GDP, GDP per capita, consumer price index (CPI), real absorption, real private consumption, real fixed investment, tax revenue, and trade between the UK and two foreign regions.

7.2.1 Real GDP, GDP per Capita and CPI

As can be seen on Table 7.2A, all five scenarios would result in an increase in real GDP of the UK, while the levels of change are different. The magnitudes of the changes in real GDP vary from one skill type of labour immigration to another. The scenario A1 (highly-skilled labour immigration) would bring about the highest change in real GDP at 0.27% (about £3.21 billion), which is about double of the change in scenario A2 (skilled labour immigration).

Table 7.2A Impacts on UK economic growth under Group A scenarios (+1%)

	Baseline value	Scenarios' results: Percentage deviations ($\Delta\%$)				
		A1	A2	A3	A4	A5
Real GDP (Billion £)	1189.47	0.269	0.139	0.069	0.050	0.527
GDP per capita (thousand £)	19.879	0.141	0.014	-0.073	-0.045	0.036
Consumer price index (CPI)	1.077	-0.029	-0.014	-0.016	-0.003	-0.062

Similarly, scenario A2 also causes almost twice in real GDP change than scenario A3 (semi-skilled labour immigration) of 0.07%, while scenario A4 (unskilled labour immigration) only increases real GDP by 0.05%. These results indicate that the higher the skill of immigration labour occurred, the higher the real GDP growth brought by immigration labour to UK economy will be expected. The scenario A5 results in an increase in the real GDP at 0.53%.

Table 7.3 Impacts of increasing labour immigration on the growth of real GDP (% change)

($\Delta\%$)	Highly-skilled	Skilled	Semi-skilled	Unskilled	All
1	0.269	0.139	0.069	0.050	0.527
2	0.534	0.275	0.137	0.098	1.043
3	0.794	0.409	0.202	0.146	1.547
4	1.049	0.541	0.265	0.192	2.041
5	1.299	0.671	0.327	0.237	2.524
6	1.545	0.798	0.386	0.281	2.997
7	1.786	0.923	0.444	0.324	3.459
8	2.023	1.046	0.501	0.366	3.912
9	2.255	1.166	0.555	0.407	4.354
10	2.483	1.285	0.608	0.446	4.787

The results of Group B scenarios in Table 7.2B also show an increase in the real GDP, but the percentage of changes are much larger than scenario B1 at 2.48%, B2 at 1.29%, B3 at 0.61% and B4 at 0.45%. Similarly with scenario A5, the percentage change of real GDP by scenario B5 is also small than the sum of scenario B1, B2, B3 and B4. In order to have a better understanding, the responses of real GDP to the shock of varying degrees of labour supply on the UK are illustrated in the Table 7.3. Table 7.3 shows that in terms of real GDP, all types of immigration labour make positive contribution by 0.53%, and the higher the skill level of labour force, the larger the contribution immigration labour will make to the domestic economy.

Table 7.2B Impacts on UK economic growth under Group B scenarios (+10%)

	Baseline value	Scenarios' results: Percentage deviations ($\Delta\%$)				
		B1	B2	B3	B4	B5
Real GDP (Billion £)	1189.47	2.483	1.285	0.608	0.446	4.787
GDP per capita (thousand £)	19.879	1.182	0.034	-0.802	-0.498	-0.115
Consumer price index (CPI)	1.077	-0.268	-0.128	-0.142	-0.026	-0.563

As argued by the Parliamentary Report (House of Lords, 2008), using GDP per capita, by taking into account of the increase in UK's population via immigration, seems a more appropriate indicator for assessing the impact of immigration on welfare than using real GDP alone. Table 7.2A shows scenario A1 and A2 have a positive

contribution to GDP per capita by 0.14% and 0.01%, respectively; however, scenario A3 and A4 have the negative effects by -0.07% and -0.05%. Contrast to the assessment of the contribution to GDP discussed above, the measure of GDP per capita explicitly illustrate that it is the higher-skilled (not any kind of) labour which makes contribution to UK economy in the long-term view.

Scenario A5 shows that if all types of labour supply increases by 1%, the GDP per capita would increase by 0.04%. The results of Group B scenarios in Table 7.2B show that 10% increase in each type of immigration labour would cause the percentage of change of GDP per capita increase about 8 times from A1 to B1, 3 times from A2 to B2, but decrease about 11 times for both from A3 to B3 and from A4 to B4. The enlargement of all types of immigration labour just magnified the picture and enhanced the points made above, i.e., only highly-skilled labour force brings positive impact on UK economy in the long run.

Table 7.2C Impacts on UK economic growth under Group C scenarios (-1%)

	Baseline value	Scenarios' results: Percentage deviations ($\Delta\%$)				
		C1	C2	C3	C4	C5
Real GDP (Billion £)	1189.47	-0.274	-0.141	-0.071	-0.051	-0.539
GDP per capita (thousand £)	19.879	-0.146	-0.016	0.071	0.044	-0.048
Consumer price index (CPI)	1.077	0.029	0.014	0.017	0.003	0.063

In order to examine the influence of different types of immigration labour, a scenario with 1% decrease of labour inflow has presented in Table 7.2C. Its results show that the 1% reduction of any type of labour would have a negative impact on real GDP; in terms of GDP per capita, the reduction of highly-skilled and skilled labour have negative effects, but the effects of decreasing semi-skilled and unskilled labour are positive as the result of the reduction of social welfare burden.

The results of consumer price index (CPI) show that all scenarios have the negative effects. In 1% increase of labour immigration, scenario A1 has the largest effect at -0.03%, followed by scenario A3 at -0.02%, then scenario A2 at -0.01% and scenario A4 at -0.003%. In large scale labour immigration, shown in Table 7.2B, the results of simulations also show enlarged negative effects by different types of labour immigration. Although the skilled labour have higher productivity and contribute more to GDP, they consume more everyday products than the semi-skilled labour which cause smaller effect on the CPI. Therefore, the increase in supply of highly-skilled and semi-skilled labour could result in larger deflationary pressures on UK economy. The impacts of overall labour immigration on CPI are also negative, i.e., -0.06% in scenario A5 and -0.56% in scenario B5.

Table 7.2C shows that CPIs of all scenarios from C1 to C5 are positive (i.e., increase from the baseline), this means an increase of consumer prices of all commodities. This phenomenon can be explained by increase of prices of composite commodities (PQ) given the shares of each commodity in total demand unchanged. ΔPQ with a positive figure can happen only in three circumstances: 1) increase the total value of domestic produced commodities excluded exports with no change of domestic demand for consumer commodities; 2) increase of the former is faster than the increase of the latter; 3) decrease of the former is slower than the decrease of the latter.

Under the scenarios C group, the first and second cases hardly happen as reduction of the labour input; only the last case can be used to describe the simulated results: reducing any type of immigration labour would result a reduction of the total value of domestic produced commodities and the domestic demand for consumer commodities, but at different paces, the former is much slower than the latter. This consequently leads to an increase of CPI; hence, to worsen the domestic economic development environment.

In brief, these results indicate the following three points:

- 1) the higher the skill of immigration labour occurred, the higher the real GDP growth brought by immigration labour to UK economy will be expected.
- 2) the measure of GDP per capita explicitly illustrate that it is the higher-skilled (not any kind of) labour which makes contribution to UK economy in the long-term view.
- 3) reducing any type of immigration labour would lead to an increase of CPI; hence, to worsen the domestic economic development environment.

The insights above provide some further evidence to prove the view of some existing literature. It is largely recognised that an increase in higher-skilled immigration has unambiguously positive effects on growth by many researches (Blattner and Sheldon, 1989; Brestschger, 2001), but that the effects of lower-skilled immigration are negative on the GDP per capita has only been recognised by very limited studies (Brucker and Kohlhas, 2002).

7.2.2 Private Consumption, Fixed Investment, Absorption and Tax Revenue

In general, GDP consists of private consumption, government consumption, fixed investment, stock change, total exports and imports. The current study takes the specified model closure of a saving-driven balance; domestic saving is directly linked to the household income (so do private consumption and fixed investment); the household income is mainly from the wages of labour forces. Therefore, the participation of different skilled immigration labour force to a large extent would influence all aspects mentioned above, such as private consumption, fixed investment, absorption and tax revenue, as immigrants are consumers as well as producers.

Table 7.4A Impacts on absorption, private consumption, fixed investment and tax revenue (+1%)

	Baseline value	Scenarios' results: Percentage deviations ($\Delta\%$)				
		A1	A2	A3	A4	A5
Real Absorption (Billion £)	1229.82	0.270	0.141	0.072	0.042	0.526
Private consumption (Billion £)	781.92	0.147	0.072	0.042	0.027	0.288
Fixed investment (Billion £)	190.59	1.142	0.619	0.297	0.160	2.211
Indirect Tax Revenue (Billion £)	156.49	0.321	0.167	0.082	0.064	0.634

From Tables 7.4A, one can see that the economic impacts of immigration labour on real private consumption and real fixed investment have the similar changing pattern with real GDP under different scenarios. The higher skilled the labour immigration is, the larger the percentage changes in both real private consumption and real fixed investment will be. Compared with the increase in real private consumption, the increase in real fixed investment seems even more dramatic, for example, in scenario A1, real fixed investment increases by 1.14%, while real private consumption increase only about 0.15%. This may imply that the immigration labour force plays a bigger role in promoting economic growth rather than in stimulating domestic consumption; this is due to newly immigration labour forces function more like producers rather than consumers, as they come to the UK left their families in their home country.

Moreover, real absorption, which is equal to national income minus balance of trade, has a similar changing pattern with real GDP. The results in Tables 7.4A and 7.4B show that labour immigration usually bring about more changes in real absorption than in real GDP. The explanation for this phenomenon is the same as the interpretation for the real GDP and GDP per capita; apart from the small effect of unskilled immigration labour, compared with its effect on real GDP, this is mainly caused by the volume of imported goods which consists of absorption (the detail about trade will be discussed soon after).

Tax revenue includes direct and indirect tax revenues. Indirect tax revenue is collected by an intermediary from the person who bears the ultimate economic burden of the tax. Table 7.4A shows that 1% increase in highly-skilled labour supply (scenario A1) would increase tax revenue by 0.32%, skilled labour by 0.13%, semi-skilled labour by 0.07% and unskilled labour by 0.04%. It clearly reveals that higher-skilled immigration labour would contribute more indirect tax to the UK government. Increasing tax revenue means to increase government expenditure, which in turn would improve public welfare to the society.

Table 7.4B Impacts on absorption, private consumption, fixed investment and tax revenue (+10%)

	Baseline value	Scenarios' results: Percentage deviations ($\Delta\%$)				
		B1	B2	B3	B4	B5
Real Absorption (Billion £)	1229.82	2.484	1.306	0.634	0.376	4.750
Private consumption (Billion £)	781.92	1.383	0.671	0.367	0.244	2.697
Fixed investment (Billion £)	190.59	10.355	5.672	2.588	1.430	19.586
Indirect Tax Revenue (Billion £)	156.49	2.947	1.545	0.722	0.577	5.739

7.2.3 International Trade

It is widely agreed that trade liberalization and labour free movement are complementary rather than substitution (Razin and Sadka, 2000). A number of recent empirical studies found that immigration has a positive effect on trade. In order to find out the different impacts of immigration labour on trade, this study divides the overseas trading partners into two modes, rest of EU countries (ROE) and rest of world excluding EU (ROW).

The UK economy has been an open economy with intensive trade with both ROE and ROW for a long history. Nowadays, international trade is one of the most important parts of UK economy. For the modelling simulation in this study, exchange rates to both

EMU zone and rest of world have been treated as fixed.

Table 7.5A Impacts on international trade under Group A scenarios (+1%)

	Baseline value	Scenarios' results: Percentage deviations ($\Delta\%$)				
		A1	A2	A3	A4	A5
Exports to ROW(Billion £)	150.19	0.271	0.132	0.055	0.072	0.531
Exports to ROE(Billion £)	158.02	0.254	0.125	0.051	0.093	0.523
Imports from ROW(Billion £)	-155.86	0.269	0.140	0.067	0.055	0.531
Imports from ROE(Billion £)	-192.69	0.265	0.137	0.065	0.049	0.515

The following conclusive points have been drawn from Table 7.5A:

- 1) The overall results show that labour immigration as the whole has the positive effects on both exports and imports either with ROE or with ROW by rates from 0.51% to 0.53%.
- 2) For both exports and imports, the results clearly show that the higher the skill of immigration labour force have, the larger the impacts on international trade they make. For example, highly-skilled immigration labour has largest effects by 0.27% for ROW and 0.25% for ROE.
- 3) An interesting point worth to be noticed is that unskilled immigration labour has larger effects on total exports than semi-skilled has. This can be explained by the variation of domestic production prices; as the Heckscher-Ohlin-Samuelson (HOS) model tells us the effect of immigration on an open economy will depend on the relative prices of traded goods (Pouliakas *et al.*, 2008). The theory exactly reflects to the fact that unskilled immigration labour has the larger effects on the reduction of domestic production prices than semi-skilled does in UK economy today (the detail will be discussed in section 7.5.2 of this thesis).
- 4) Considering the effects on ROW and ROE, scenario A1, A2 and A3 all have larger

- effects on export to ROW, while scenario A4 has larger effect on exports to ROE. One possible explanation for this is due to the fact that there is more homogeneity between the UK market and EU market, and more heterogeneity between the UK market and the world market. The commodities produced by skilled labour in the UK may concentrate on manufactured goods with high-tech element which may be more competitive in the world market with relatively lower prices due to the lower labour costs, and the commodities produced by the UK with low skill may be more popular in the EU market as the result of their relatively low labour costs.
- 5) The immigration labour will have larger impact on stimulating imports than promoting exports, only scenario A4 shows an opposite effects; this might cause a slight worrying of worsening in the balance of payment (BoP). Nevertheless, scenario A5 indicates that the overall effects on export and import are almost the same.

7.3 Impacts on Labour Market

The increasing supply of a type of labour would directly stimulate the competition for job seeking which will bring about the decrease of wage but increase of unemployment rate on relevant labour. The conventional economic paradigm predicts that immigration to small local economies is expected to lead to falling returns to particular skill types of labour and rising returns to complementary factors (Pouliakas *et al.*, 2008).

Is this conventional believe applicable to UK economy today? In other words, what are the impacts of immigration labour on different aspects of UK labour market, such as UK domestic labour wages, unemployment rate, employment and factors' incomes? The intension of answering this question is one of the most important objectives of the current study. The simulation results are presented in Tables 7.6, 7.7, 7.9 and 7.10, respectively.

7.3.1 Labour Wages and Unemployment Rate

The results of scenarios in Table 7.6A reveal some important points:

- 1) 1 percent highly-skilled labours immigrate into the UK would reduce local highly-skilled labour wage by 0.76% and skilled labour by 0.16%, and increase the wages of semi-skilled and unskilled labour by 0.01% and 0.23%, respectively. The former is due to the highly-skilled immigration labour intensify the job competition in labour market not only within themselves but also between highly-skilled group and existing highly-skilled and skilled labour; the latter is as the consequences of complementary relation between the higher-skilled labour group and lower-skilled labour group.

Table 7.6A Impacts on wages under Group A scenarios (+1%)

	Baseline value (£ ,000)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario A1	Scenario A2	Scenario A3	Scenario A4	Scenario A5
Highly-skilled labour	39.76	-0.757	-0.076	0.003	0.011	-0.819
Skilled labour	22.10	-0.164	-0.690	0.0004	0.012	-0.840
Semi-skilled labour	14.87	0.007	0.001	-0.564	-0.012	-0.568
Unskilled labour	14.71	0.229	0.122	0.007	-0.557	-0.208

- 2) Scenario A2 also shows that skilled labour immigration will decrease the highly-skilled and skilled labour's wage by -0.08% and -0.69%, and increase the wages of semi-skilled and unskilled labour by 0.001% and 0.12%, respectively.
- 3) Scenario A3 shows that semi-skilled labour immigration only causes adverse effects on local semi-skilled labour, and has favourable effects on all other labours' wages.
- 4) Scenario A4 shows positive effects on the wages of both highly-skilled and

skilled labour at 0.01%, while negative effects for the semi-skilled labour and themselves at -0.01% and -0.56%, respectively.

The Scenario A5 gives an overall picture of all types immigrations labour on the local labour market. It clearly indicates that immigration has larger negative effects on the wages of higher-skilled labour (between -0.82% and -0.84%) than that of lower-skilled labour (between -0.21% and -0.57%). The results provide some important and clear insights and policy implication: highly-skilled labour inflow will lessen wage inequality among different skill types of labours; lower-skilled immigration labour will increase the wages of the higher-skilled group, but worsen the wage of lower-skilled group, hence to further enlarge the gap of social wages.

The results of Scenario B1 in Table 7.6B show that the wage of highly-skilled labour would drop considerably by -6.84% when a large scale of 10% increases in domestic highly-skilled labour supply cause by labour immigration. The results show that the unskilled labour would have the largest benefit that the wage is increased by 2.18%. Scenario B2 reduces the wage of skilled labour by 6.22%, the wage of semi-skilled labour falls by 4.84% in Scenario B3 and unskilled labour decreases its wage by 4.87% in Scenario B4. Scenario B5 has the reduction on all labour types' wages, especially on higher-skilled and skilled labour both at about -7%.

Table 7.6B Impacts on wages under Group B scenarios (+10%)

	Baseline value (£ ,000)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario B1	Scenario B2	Scenario B3	Scenario B4	Scenario B5
Highly-skilled labour	39.76	-6.836	-0.702	0.025	0.099	-7.353
Skilled labour	22.10	-1.513	-6.216	0.004	0.102	-7.462
Semi-skilled labour	14.87	0.070	0.014	-4.838	-0.102	-4.945
Unskilled labour	14.71	2.181	1.148	0.049	-4.868	-2.213

Table 7.6C Impacts on wages under Group B scenarios (-1%)

	Baseline value (£ ,000)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario C1	Scenario C2	Scenario C3	Scenario C4	Scenario C5
Highly-skilled labour	39.76	0.775	0.077	-0.003	-0.011	0.839
Skilled labour	22.10	0.167	0.706	-0.000	-0.012	0.863
Semi-skilled labour	14.87	-0.007	-0.001	0.585	0.012	0.587
Unskilled labour	14.71	-0.231	-0.123	-0.007	0.575	0.205

On the contrary, the reduction of labour supply simulations (Group C scenarios) results in the opposite changing patterns of the impacts on wages with the former two scenario groups.

The unemployment rate, which is defined by ‘wage curve’ (Blanchflower and Oswald, 1995, discussed in section 5.4.5), mainly reflects UK specific labour market imperfection. The results of Scenario A1 in Table 7.7A show that 1 percent increase in highly-skilled labour supply by immigration would increase the unemployment rate for highly-skilled and skilled labour by 5.79% and 1.05%, but reduce the unemployment rate for semi-skilled labour by 0.28% and for unskilled labour by 1.96%. The increasing number of highly-skilled labour would cause intense competition in higher-skilled labour market, and then increase unemployment rate within the group. Similarly, scenario A2 also increases unemployment rates of highly-skilled and skilled labour, while decreases other two types of lower-skilled labour. Scenarios A3 and A4 in general have impacts opposite to scenarios A1 and A2, apart from that on itself.

It is interesting to see that along the diagonal line of the matrix, all figures are positive. It is clearly indicates that increase of labour supply will intensify the competition within the group.

Table 7.7A Impacts on unemployment rate under Group A scenarios (+1%)

	Baseline value	Percentage deviations from baseline ($\Delta\%$)				
		Scenario A1	Scenario A2	Scenario A3	Scenario A4	Scenario A5
Highly-skilled labour	0.018	5.789	0.480	-0.148	-0.109	6.024
Skilled labour	0.024	1.049	5.359	-0.129	-0.111	6.202
Semi-skilled labour	0.091	-0.275	-0.115	4.314	0.066	3.985
Unskilled labour	0.073	-1.959	-1.036	-0.176	4.368	1.137
Total	0.051	-0.188	0.209	2.379	1.304	3.653

The most important insight obtained from above analysis is that highly-skilled labour immigration had brought a strong positive impact on the British labour market. As Table 7.7A illustrating, highly-skilled labour immigration reduced the total unemployment rate by 0.19%, while other types of immigration labour group have worsen the situation in UK labour market. The clear message for the policy implication from this conclusive point is that within UK economic structure, there is lack of highly-skilled labour force, the marginal profit from highly-skilled labour is more superior to all other types.

Table 7.7B Impacts on unemployment rate under Group B scenarios (+10%)

	Baseline value	Percentage deviations from baseline ($\Delta\%$)				
		Scenario B1	Scenario B2	Scenario B3	Scenario B4	Scenario B5
Highly-skilled labour	0.018	68.88	4.54	-1.28	-0.95	72.29
Skilled labour	0.024	10.14	62.23	-1.12	-0.98	73.87
Semi-skilled labour	0.091	-2.57	-1.08	44.84	0.59	41.44
Unskilled labour	0.073	-17.03	-9.30	-1.47	46.50	13.74
Total	0.051	0.450	3.999	26.17	14.71	40.51

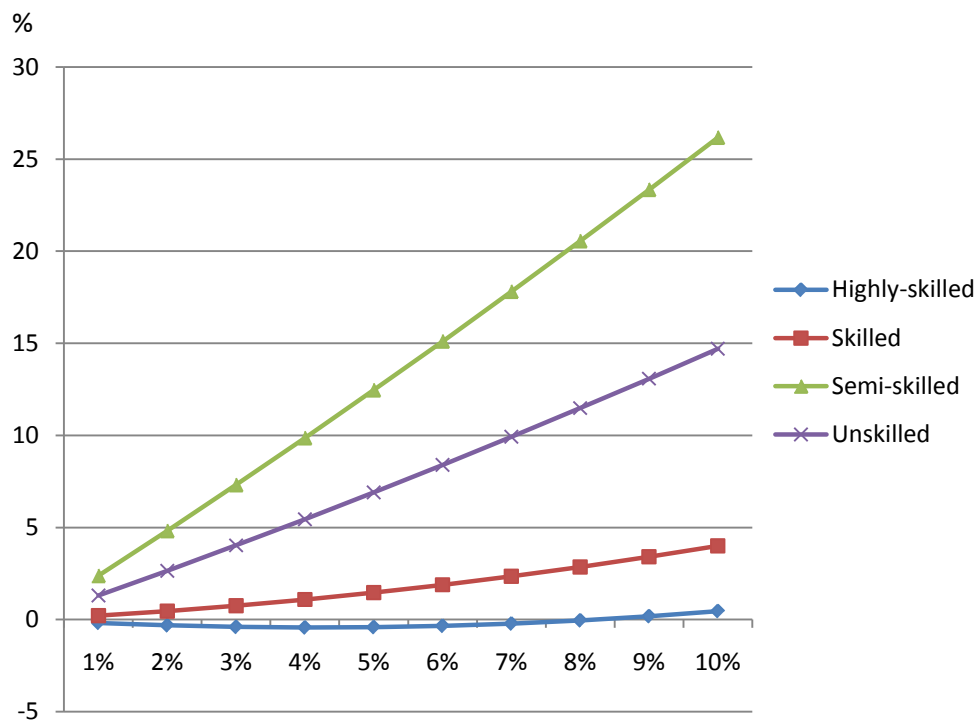
Table 7.7B displays the results of Group B scenarios on unemployment rate. The results shows that labour supply increased by 10 percent would cause dramatically increase in the relative labour's unemployment rate, such as Scenario B1 causes the unemployment rate for highly-skilled labour increased by 68.9%, Scenario B2 causes skilled labour by 62.2%, 44.8% for semi-skilled labour in Scenario B3, and 46.5% for unskilled labour in Scenario B4. Different from Scenario A1, Scenario B1 will cause the total

unemployment rate to increase by 0.45%.

Table 7.8 Impacts of different skill types of immigration labour on total unemployment rate ($\Delta\%$)

	Highly-skilled	Skilled	Semi-skilled	Unskilled
1%	-0.19	0.21	2.38	1.30
2%	-0.32	0.46	4.82	2.65
3%	-0.41	0.75	7.31	4.03
4%	-0.44	1.09	9.86	5.45
5%	-0.42	1.46	12.46	6.90
6%	-0.35	1.88	15.11	8.39
7%	-0.23	2.35	17.81	9.92
8%	-0.05	2.85	20.55	11.48
9%	0.17	3.40	23.34	13.08
10%	0.45	4.00	26.17	14.71

Figure 7.1 Impacts of increase in labour immigration on unemployment rate



In order to find out the relationship between unemployment and increasing labour immigration, Table 7.8 with Figure 7.1 present a direct visual view about the changing impacts (i.e., marginal effects) of different types of labour immigration at different speeds on UK total unemployment. It is interesting to see the following three indicative

points:

- (1) The highly-skilled immigration labour is the only one which could bring positive impacts on reducing unemployment currently;
- (2) As the supply of highly skilled immigration labour increase in proportion, the decrease of unemployment start at fast speed; and this trend continues until the point of 4% increase of the supply. This is to say, 4% increase of the supply is the turning point; beyond that point the marginal effect will be decreased until the point of 8%, the point of 8% is the optimal point, which indicates the upper limit of the highly-skilled labour inflow.
- (3) Other three types of immigration labour all play a negative role in reducing the domestic unemployment. Surprisingly, the unskilled immigration labour group has a smaller negative impact on the UK labour market than semi-skilled does. Under a unit increase of immigration labour, the negative impact of unskilled labour is about half of that of semi-skilled labour.

From the above findings, it may be reasonable to draw the following points: among all types, currently the prior demand of UK labour market is highly-skilled and unskilled labour rather than semi-skilled labour force. The explanation of this phenomenon is that the British economy is much advanced in terms of its industrial structure and its composition of different skill-levels of labour groups; there may be already enough semi-skilled and properly skilled labour, but short of both higher-end and lower-end, although the British labour market is mainly consisted of higher-skilled labour for about 15.2 million and lower-skilled labour about 14.2 million.

7.3.2 Employment and Factor Incomes

Tables 7.9 explain the impacts of labour immigration on employment. Due to the profit maximisation driving, the firms are willing to employ cheaper proper labours, regardless of domestic or immigrated. The results of scenario A1 show that a 1 percent increase of highly-skilled labour immigration would increase employment by 0.89% within the group, while it would crowd out domestic skilled labour by -0.03%, and would bring up the employment of domestic semi-skilled labour by 0.03% and unskilled labour by 0.15%. The results of skilled labour immigration scenario also show the positive effects on the employment of domestic semi-skilled and unskilled labour; it leads to 0.87% of increase employment within its own group, but negative effect on domestic highly-skilled labour.

Table 7.9A Impacts on employment under Group A scenarios (+1%)

	Baseline value (,000)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario A1	Scenario A2	Scenario A3	Scenario A4	Scenario A5
Highly-skilled labour	7,552	0.893	-0.009	0.003	0.002	0.888
Skilled labour	7,303	-0.026	0.867	0.003	0.003	0.846
Semi-skilled labour	7,736	0.028	0.012	0.564	-0.007	0.597
Unskilled labour	5,267	0.154	0.082	0.014	0.653	0.910
Total	27,857	0.272	0.243	0.161	0.123	0.800

A point worth to be noticed is that semi-skilled immigration labour has all positive figures in Table 7.9A. It implies that the semi-skilled labour has no capacity to substitute (crowd out) other types of labour from UK labour market, but interestingly unskilled immigration labour can crowd out semi-skilled labour by 0.007%. This further confirms the points made above: the semi-skilled labour is the least needed type.

The overall picture from scenario A5 explicitly demonstrates that the inflow of immigration labour plays a significant and positive role in employment in UK labour market by 0.80%. Among four scenarios, A1 (1% increase of highly-skilled) results the

largest improvement (0.27%) to UK total employment. Among the four types of labour group, unskilled labour receives the largest impact (0.91%), followed by highly-skilled, skilled and semi-skilled labour groups by 0.89%, 0.85% and 0.60%, respectively.

Factor income from labour force is a main source of households' income and an important contributor to social welfare. The simulation results show that the contributions from different skilled types of labour forces vary.

Table 7.10A Impacts on factor incomes under Group A scenarios (+1%)

	Baseline value (£ Bil.)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario A1	Scenario A2	Scenario A3	Scenario A4	Scenario A5
Highly-skilled labour	300.28	0.114	-0.096	0.009	0.016	0.042
Skilled labour	161.42	-0.182	0.175	0.005	0.013	0.009
Semi-skilled labour	115.03	0.066	0.028	0.036	-0.051	0.078
Unskilled labour	77.46	0.284	0.148	-0.022	0.114	0.524
Total	654.19	0.052	0.021	0.009	0.015	0.097
Capital	378.79	0.544	0.279	0.134	0.097	1.057

Table 7.10A also clearly shows scenario A1 (increase of 1% of highly-skilled labour) makes the largest contribution to the factor income by 0.052% which is a 2.5 times as large as the contribution of skilled labour, and A4 makes the smallest contribution by 0.015%.

Capital as one of product factors is another important contributor to factor income. However, the impact of capital's contribution varies from its combination with one type of labour or another. The bottom row of Table 7.10A obviously shows the higher the skill level of labour force the capital invested into, the larger the contribution of capital to the factor incomes will be. For example, scenario A1 has the largest increase by 0.54%, compared with scenario A4 which is only 0.10%.

To get a better understanding of the effects of scenario A5, Table 7.11 is constructed

based on the results of Tables 7.6A, 7.9A and 7.10A.

Table 7.11 Summary of percentage changes in wage, employment and factor income

	Wage	Employment	Income
Highly-skilled labour	-0.819	0.888	0.042
Skilled labour	-0.840	0.846	0.009
Semi-skilled labour	-0.568	0.597	0.078
Unskilled labour	-0.208	0.910	0.524

Note: this table is compiled based on a summary of Tables 7.6A, 7.9A and 7.10A,

By considering the impact of increase of immigration labour on factor incomes, Table 7.11 presents the overall results under scenario A5. As can be seen from Table 7.11, unskilled labour presents the largest overall impact on factor income among all four by 0.52% and skilled labour has the smallest impact as 0.01%; interestingly highly-skilled labour group has a very small impact of 0.04% this time.

To interpret this complicated picture in Table 7.11, there are two angles worth to look at:

- 1) As defined in Equation 34, factor income in general is the product of wage multiplies employment plus overseas labour income. Therefore, the impacts of different types of labour force depend not only on the change of wage level, but also on the change of the employment. Look at the unskilled labour, both wage and employment move towards its relatively favourable direction, resulting the largest positive impact on the factor income. The opposite case can be found in the skilled labour group.
- 2) As scenario A5 is a portfolio consisting of 1% increase in each skill types of immigration labour, the results in that column is not just the result of each type of labour, it also includes inter-reactive consequences of all four types. Obviously, unskilled group is the beneficial of increase in higher-skilled labour force as a fruit of the proportionate balance of skilled labour types.

7.4 Impacts on Domestic Institutions

Immigration labour has been an outstanding issue debated for many decades, but among many, what British public more concerned about are probably two issues: unemployment and social welfare, as they directly influence the quality of their life. It is witnessed that a fierce debate about these issues has been taking place on all kinds of public media, such as BBC Question Time, concentrating on the impact on household welfare and fiscal consequences. To gain a better understanding of these puzzles, the current study linked these issues to the immigration labour to simulate its impacts.

Domestic institutions consist of five income groups of households, enterprises and government. Households and enterprises receive factor incomes from the sum of factor incomes and the transfer payments from other domestic or foreign institutions. Government revenue mainly comes from direct and indirect taxation, and its expenditure is the sum of government consumption demand plus transfers to other institutions.

7.4.1 Incomes and Expenditure of Domestic Institution

The impacts of labour immigration on domestic institutions' income are shown in Tables 7.12. The results show that all skill types of immigration labour make positive contribution to incomes of all institutions. Among all institutions, the great income benefit from immigration labour goes to enterprises (1.06% increase); the government also receives second largest benefit (0.59% increase); and households benefit vary from one group to another (from 0.17 to 0.32%, refer to Table 7.12A). Among the household groups, HH2 and HH3 seem to get larger benefits than HH1 and HH5 are.

Table 7.12A Impacts on domestic institutions' income under Group A Scenarios

	Baseline value (Billion £)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario A1	Scenario A2	Scenario A3	Scenario A4	Scenario A5
HH1	72.52	0.09	0.05	0.01	0.02	0.17
HH2	126.72	0.17	0.09	0.03	0.03	0.32
HH3	190.52	0.13	0.08	0.03	0.03	0.27
HH4	247.08	0.10	0.05	0.02	0.02	0.20
HH5	323.52	0.10	0.03	0.02	0.02	0.17
Enterprise	260.42	0.54	0.28	0.13	0.10	1.06
Govt.	388.64	0.31	0.16	0.08	0.05	0.59

In terms of the contribution made by different types of immigration labour, the results in Table 7.12A show that the contribution made by the highly-skilled is about five times (0.54 : 0.10) as higher as that of the unskilled to enterprises, about six times (0.31 : 0.05) to government, and about five times to households. Without surprising, this is in line with the trends in the aspects as discussed in the previous sections (such as GDP, private consumption and fixed investment), i.e. the higher the skill of labour force, the larger the contribution they make. This is because higher-skilled labour earn higher wage, thus should make a great tax revenue to the government.

What is the most interesting point need to be noticed is that, in terms of contribution made by semi-skilled and unskilled, the latter seems to make a larger contribution to low income groups (HH1 and HH2) than the former. This can be explained by the fact that the unskilled labour themselves are largely classified as low income classes; under scenario A4, an increase of unskilled immigration labour, giving other things equal, will mostly benefit low income classes.

Opposite to the results of in Table 7.12A, the results in Table 7.12C present all negative figures. It clearly indicates that reducing immigration labour would result a reduction of incomes to all entities of institution.

Table 7.12C Impacts on domestic institutions' income under Group C Scenarios

	Baseline value (Billion £)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario C1	Scenario C2	Scenario C3	Scenario C4	Scenario C5
HH1	72.52	-0.094	-0.049	-0.012	-0.020	-0.175
HH2	126.72	-0.172	-0.092	-0.031	-0.035	-0.329
HH3	190.52	-0.135	-0.083	-0.029	-0.029	-0.275
HH4	247.08	-0.107	-0.053	-0.024	-0.024	-0.207
HH5	323.52	-0.098	-0.032	-0.024	-0.022	-0.177
Enterprise	260.42	-0.550	-0.283	-0.138	-0.099	-1.068
Govt.	388.64	-0.312	-0.160	-0.078	-0.054	-0.603

The results of impacts on households and the government's expenditure are shown in Tables 7.13A and 7.13B. As the expenditure of households relies mainly on their incomes, so the impacts of international labour immigration on households' expenditure follow the same pattern as the impacts on households' incomes. In terms of government expenditure, 1 percentage increase of immigration labour has positive impacts by bringing down it by 0.31% and 10 percentage by -2.81%, but the effects vary from one skill type to another, the higher the skill of immigration labour has, the larger the effect they will bring. There are two possible reasons which can explain the phenomenon: 1) the composite prices of Public Administration and Education sector and other Services sector (which are only two sectors related to government expenditure) have decreased as the increase of immigration labour (refer to section 7.5.2); 2) the transfer payments from the government to higher-skilled labour is much smaller than that to unskilled labour.

Table 7.13A Impacts on domestic institutions' expenditure under Group A Scenarios

	Baseline value (Billion £)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario A1	Scenario A2	Scenario A3	Scenario A4	Scenario A5
HH1	71.14	0.09	0.05	0.01	0.02	0.17
HH2	116.95	0.17	0.09	0.03	0.03	0.32
HH3	158.79	0.13	0.08	0.03	0.03	0.27
HH4	195.98	0.10	0.05	0.02	0.02	0.20
HH5	239.05	0.10	0.03	0.02	0.02	0.17
Govt.	397.93	-0.17	-0.10	-0.04	-0.0005	-0.31

The impacts of reducing immigration labour on expenditure by 1% (presenting in Table 7.13C) just show an opposite direction of change to Table 7.13A; but with different paces as they are not linear relationships.

Table 7.13B Impacts on domestic institutions' expenditure under Group B Scenarios

	Baseline value (Billion £)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario B1	Scenario B2	Scenario B3	Scenario B4	Scenario B5
HH1	71.14	0.714	0.366	-0.165	-0.210	0.649
HH2	116.95	0.861	0.317	-0.389	-0.492	0.166
HH3	158.79	-0.319	-0.529	-0.579	-0.419	-1.942
HH4	195.98	-1.856	-1.094	-0.528	-0.321	-3.828
HH5	239.05	-3.003	-1.425	-0.265	-0.022	-4.635
Govt.	397.93	-1.558	-0.949	-0.359	-0.005	-2.808

Table 7.13C Impacts on domestic institutions' expenditure under Group C Scenarios

	Baseline value (Billion £)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario C1	Scenario C2	Scenario C3	Scenario C4	Scenario C5
HH1	71.14	-0.09	-0.05	-0.01	-0.02	-0.18
HH2	116.95	-0.17	-0.09	-0.03	-0.04	-0.33
HH3	158.79	-0.13	-0.08	-0.03	-0.03	-0.28
HH4	195.98	-0.11	-0.05	-0.02	-0.02	-0.21
HH5	239.05	-0.10	-0.03	-0.02	-0.02	-0.18
Govt.	397.93	0.17	0.10	0.04	0.001	0.32

7.4.2 Welfare of Domestic Households

Welfare is measured by Equivalent Variation (EV), the monetary equivalent of how much better off (worse off) households are after the labour shock compared to their base welfare level (Pouliakas *et al.*, 2008). EV is measured by using the following formula:

$$EV = IC - EH$$

Where, IC measure the consumption value needed at base prices to generate the same welfare; EH measures the household consumption expenditure at base prices before the labour shock. The measure provides a better basis for evaluation of impacts compared to just looking at changes in households income or wage changes independently.

Table 7.14A Impacts on domestic households' welfare (Equivalent Variation) under Group A Scenarios (Billion £)

	Percentage deviations from baseline				
	Scenario A1	Scenario A2	Scenario A3	Scenario A4	Scenario A5
HH1	0.08	0.04	0.03	0.02	0.17
HH2	0.23	0.12	0.06	0.04	0.45
HH3	0.26	0.15	0.08	0.05	0.53
HH4	0.26	0.13	0.08	0.05	0.52
HH5	0.32	0.12	0.09	0.05	0.58
TOTAL	1.15	0.56	0.33	0.21	2.25

The welfare effects of immigration labour are reported in Table 7.14A for Group A scenarios and 7.14B for Group B. By looking at the result in the scenario A5, which provide an overall picture of the changes, one can draw the following points:

- 1) The welfare levels for all households have been improved from £0.17 billion to £0.58 billion; obviously, as a result of proportionate change, the high income classes gain more in absolute value than the low income classes.
- 2) Highly-skilled immigration labour generates the largest welfare than other types of labour. Its impact on the highest income class (HH5) is 2.7 times as high as the skilled, 3.6 times as high as the semi-skilled and 6.4 times as high as the unskilled. Its impact on the lowest income class (HH1) is 2 times as high

as the skilled, 2.7 times as high as the semi-skilled and 4 times as high as the unskilled.

- 3) The higher the skill levels of immigration labour, the larger the contribution to households' welfare they generate.

Table 7.14B indicates the same direction of movement as Table 7.14A, but the magnitude of change is as large as ten times of the initial value in Table 7.14A. A reverse effect from the baseline scenario can be found in Table 7.14C, i.e., decrease immigration labour by 1%. Without surprise, the direction of changes is the opposite of Table 7.14A again.

Table 7.14B Impacts on domestic households' welfare (Equivalent Variation) under Group B Scenarios (Billion £)

	Percentage deviations from baseline				
	Scenario B1	Scenario B2	Scenario B3	Scenario B4	Scenario B5
HH1	0.79	0.39	0.23	0.15	1.60
HH2	2.15	1.12	0.50	0.39	4.24
HH3	2.42	1.40	0.67	0.43	4.97
HH4	2.45	1.19	0.70	0.45	4.81
HH5	2.97	1.14	0.77	0.48	5.38
TOTAL	10.79	5.24	2.86	1.90	21.00

Table 7.14C Impacts on domestic households' welfare (Equivalent Variation) under Group C Scenarios (Billion £)

	Percentage deviations from baseline				
	Scenario C1	Scenario C2	Scenario C3	Scenario C4	Scenario C5
HH1	-0.09	-0.04	-0.03	-0.02	-0.17
HH2	-0.23	-0.12	-0.06	-0.05	-0.46
HH3	-0.26	-0.15	-0.08	-0.05	-0.54
HH4	-0.27	-0.13	-0.08	-0.05	-0.53
HH5	-0.32	-0.12	-0.09	-0.06	-0.59
TOTAL	-1.17	-0.57	-0.34	-0.22	-2.28

7.5 Impacts on Production Sectors

In order to choose the proper labour to immigrate, it is important to find out how domestic production across sectors will be affected by the different types of labour immigration. The impacts of labour immigration on production sectors are mainly reflected on the changes in: 1) production labour demand; 2) the prices of production and outputs; 3) the quantities of production and outputs.

7.5.1 Changes of Labour Demand in Sectors

The production labour demand is defined by the four-level nested Constant Elasticity Substitution (CES) production function in the CGE-ILA model. Table 7.15 shows the baseline value of quantity of labour demand by different sectors. It is obviously shown that the highly-skilled labours are mainly employed in the Tertiary Industry (sector 5–9), especially in sector 7 and 8. The skilled and semi-skilled labours are also focus on the Tertiary Industry, while the Secondary Industry (sector 3 and 4) employs the most unskilled labour. Moreover, the Primary Industry (sector 1 and 2) demands the fewest labour.

Table 7.15 Baseline value of labour demand (thousand) by sectors

Sectors	Highly-skilled	skilled	semi-skilled	unskilled
1 Agriculture	37.8	23.7	96.3	198.3
2 Energy and Water supply	88.0	68.9	38.9	69.8
3 Manufacturing	947.6	736.9	421.9	1666.7
4 Construction	389.7	290.7	239.9	1366.4
5 Distribution and Hotel	1236.0	691.3	2845.2	796.9
6 Transport and Communication	332.6	337.6	569.8	661.9
7 Finance and Business Services	1748.9	1764.3	667.3	157.1
8 Public Admin. and Education	2431.5	2855.4	2184.5	198.3
9 Other service	340.2	533.8	672.2	151.3

Source: ILO

The results in Tables 7.16, 7.17, 7.18, 7.19 and 7.20 show the percentage change of

labour demand in sectors under the scenarios of different types of labour immigration.

By looking at these tables, there are some important points:

- 1) Increasing (reducing) the specified skill level of labour supply by immigration labour has positive (negative) effect on the employment of this type of labour force in all industrial sectors, due to the reduction (increase) of wages. For example, Table 7.16 shows 1% increase of highly-skilled immigration labour brings up the employment of highly-skilled labour from 0.61% to 2.34% in all sectors, of which employment of Construction sector has the largest increase.
- 2) There exists a competitive relationship between highly-skilled and skilled labours, and between semi-skilled and unskilled labours, as one can see in Table 7.16, increase of highly-skilled immigration labour would crowd out skilled labour in Finance and Business Services and Public Administration and Education sectors, and in Table 7.18 the increase of semi-skilled immigration labour brings down the employment of unskilled labour in most sectors. In the meantime, there seems also exist a complementary relation between higher-skilled and lower-skilled, for example, the increase of highly-skilled or skilled labour supply has the positive effects on the demand of semi-skilled and unskilled labour in Energy and Water Supply and Construction sectors.
- 3) Increase of higher-skilled labour is helpful to balance the structure of labour market. The results shown in Tables 7.16 and 7.17 reveal that increase of higher-skilled immigration labour has positive effects on the employment of all skill types of labour force in most sectors. On the contrary, increase of lower-skilled labour will worsen the balance of labour market that either semi-skilled or unskilled immigration labour would cause the reduction of employment of other skilled labour force in the majority of sectors, as can be seen in Tables 7.18 and 7.19.

- 4) The direction and scope of the impact also depend on the nature of industrial sectors themselves, such as the specific role of a sector played in the national economic system, and the professional knowledge/skills required by a particular sector. For example, 1% increase of one skill type of immigration labour will always lead to an increase in the employment of all other types of labour force in Energy and Water supply, Construction and Finance and Business Services sectors. The explanation of this phenomenon is that industries all pursue the profit maximisation, using CES production functions to choose the best composition of labour input, as explained in section 5.3.3 above.

- 5) In general, the increase of immigration labour to the UK labour market is a threat to domestic existing employees and the labour force in the pool, but it is an opportunity for employers in different industrial sectors to employ cheaper labour force and reduce labour cost. As the new entry of immigration labour force would intensify the competition and lower the existing levels of wages.

Table 7.16 Percentage change of labour demand by scenarios of highly-skilled labour immigration

Sectors	Scenario A1 ($\Delta\%$)				Scenario B1 ($\Delta\%$)				Scenario C1 ($\Delta\%$)			
	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4
Agriculture	1.12	0.40	0.19	-0.19	10.87	3.72	1.71	-1.83	-1.12	-0.40	-0.19	0.19
Energy and Water supply	1.03	0.25	0.57	0.19	9.98	2.32	5.41	1.73	-1.04	-0.26	-0.58	-0.20
Manufacturing	0.96	0.18	0.20	-0.22	9.22	1.61	1.81	-2.15	-0.97	-0.18	-0.20	0.22
Construction	2.34	1.61	1.60	1.18	23.26	15.31	15.21	10.73	-2.34	-1.63	-1.62	-1.20
Distribution and Hotel	0.86	0.20	0.00	-0.16	8.32	1.89	-0.02	-1.47	-0.87	-0.21	0.00	0.16
Transport and Communication	0.96	0.06	0.05	-0.28	9.23	0.50	0.43	-2.66	-0.96	-0.06	-0.05	0.29
Finance and Business Services	0.90	0.00	0.21	0.08	8.60	-0.08	1.94	0.67	-0.90	0.00	-0.22	-0.08
Public Admin. and Education	0.61	-0.35	-0.25	-0.45	5.81	-3.19	-2.28	-4.10	-0.62	0.35	0.25	0.45
Other Services	1.04	0.02	0.12	-0.08	10.06	0.14	1.06	-0.82	-1.04	-0.02	-0.12	0.08

Note: L1: Highly-skilled labour, L2: skilled labour, L3: semi-skilled labour, L4: unskilled labour

Table 7.17 Percentage change of labour demand by scenarios of skilled labour immigration

Sectors	Scenario A2 ($\Delta\%$)				Scenario B2 ($\Delta\%$)				Scenario C2 ($\Delta\%$)			
	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4
Agriculture	0.20	0.94	0.10	-0.10	1.82	9.05	0.95	-0.97	-0.20	-0.95	-0.10	0.10
Energy and Water supply	0.12	0.92	0.29	0.09	1.10	8.90	2.77	0.82	-0.12	-0.93	-0.30	-0.09
Manufacturing	0.08	0.89	0.11	-0.12	0.73	8.50	1.00	-1.14	-0.08	-0.89	-0.11	0.12
Construction	0.86	1.60	0.87	0.64	8.03	15.70	8.16	5.87	-0.87	-1.61	-0.88	-0.65
Distribution and Hotel	0.11	0.79	0.01	-0.07	0.99	7.54	0.11	-0.67	-0.11	-0.79	-0.01	0.07
Transport and Communication	-0.03	0.90	0.01	-0.17	-0.31	8.61	0.05	-1.63	0.03	-0.90	-0.01	0.18
Finance and Business Services	0.02	0.95	0.11	0.04	0.19	9.15	1.02	0.34	-0.02	-0.96	-0.11	-0.04
Public Admin. and Education	-0.25	0.74	-0.15	-0.26	-2.34	7.01	-1.41	-2.41	0.26	-0.74	0.16	0.27
Other Services	-0.12	0.94	0.05	-0.06	-1.08	9.01	0.47	-0.54	0.12	-0.94	-0.05	0.06

Table 7.18 Percentage change of labour demand by scenarios of semi-skilled labour immigration

Sectors	Scenario A3 ($\Delta\%$)				Scenario B3 ($\Delta\%$)				Scenario C3 ($\Delta\%$)			
	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4
Agriculture	-0.09	-0.09	0.78	-0.19	-0.81	-0.78	7.07	-1.67	0.09	0.09	-0.80	0.20
Energy and Water supply	0.08	0.09	0.79	-0.18	0.74	0.76	7.16	-1.58	-0.09	-0.09	-0.81	0.19
Manufacturing	0.02	0.02	0.98	-0.11	0.14	0.17	8.90	-0.98	-0.02	-0.02	-1.00	0.11
Construction	0.35	0.35	1.34	0.24	3.03	3.06	12.29	2.10	-0.36	-0.36	-1.36	-0.25
Distribution and Hotel	-0.06	-0.06	0.52	0.12	-0.55	-0.53	4.68	1.08	0.06	0.06	-0.54	-0.13
Transport and Communication	-0.06	-0.06	0.67	-0.19	-0.54	-0.50	6.01	-1.66	0.06	0.06	-0.69	0.20
Finance and Business Services	0.05	0.06	0.44	0.10	0.48	0.51	3.96	0.88	-0.06	-0.06	-0.46	-0.10
Public Admin. and Education	-0.06	-0.05	0.46	-0.06	-0.49	-0.46	4.08	-0.51	0.06	0.05	-0.47	0.06
Other Services	0.02	0.02	0.53	0.01	0.14	0.17	4.74	0.12	-0.02	-0.02	-0.54	-0.01

Table 7.19 Percentage change of labour demand by scenarios of unskilled labour immigration

Sectors	Scenario A4 ($\Delta\%$)				Scenario B4 ($\Delta\%$)				Scenario C4 ($\Delta\%$)			
	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4
Agriculture	-0.14	-0.14	-0.24	0.69	-1.29	-1.29	-2.17	6.31	0.15	0.15	0.25	-0.70
Energy and Water supply	0.11	0.11	-0.23	0.71	1.00	1.00	-2.02	6.47	-0.11	-0.11	0.23	-0.72
Manufacturing	-0.02	-0.02	-0.31	0.73	-0.14	-0.15	-2.76	6.71	0.02	0.02	0.32	-0.75
Construction	-0.01	-0.01	-0.32	0.72	-0.07	-0.07	-2.89	6.57	0.01	0.01	0.33	-0.73
Distribution and Hotel	-0.01	-0.01	0.06	0.44	-0.05	-0.05	0.51	4.01	0.01	0.01	-0.06	-0.45
Transport and Communication	-0.06	-0.06	-0.13	0.69	-0.53	-0.53	-1.18	6.34	0.06	0.06	0.13	-0.70
Finance and Business Services	0.03	0.03	0.06	0.39	0.29	0.28	0.51	3.50	-0.03	-0.03	-0.06	-0.39
Public Admin. and Education	0.00	0.00	0.02	0.51	-0.02	-0.03	0.16	4.66	0.00	0.00	-0.02	-0.52
Other Services	0.02	0.02	0.04	0.53	0.14	0.14	0.32	4.84	-0.02	-0.02	-0.04	-0.54

Table 7.20 Percentage change of labour demand by scenarios of all types of labour immigration

Sectors	Scenario A5 ($\Delta\%$)				Scenario B5 ($\Delta\%$)				Scenario C5 ($\Delta\%$)			
	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4
Agriculture	1.07	1.10	0.83	0.21	10.25	10.41	7.34	2.29	-1.08	-1.11	-0.85	-0.21
Energy and Water supply	1.35	1.38	1.44	0.82	13.15	13.33	13.49	8.15	-1.36	-1.39	-1.45	-0.81
Manufacturing	1.04	1.07	0.97	0.28	9.80	9.97	8.53	2.84	-1.05	-1.08	-1.00	-0.28
Construction	3.55	3.58	3.50	2.79	35.00	35.19	33.59	26.59	-3.55	-3.58	-3.52	-2.82
Distribution and Hotel	0.90	0.92	0.59	0.34	8.65	8.79	5.42	3.35	-0.91	-0.93	-0.61	-0.34
Transport and Communication	0.80	0.84	0.59	0.05	7.59	7.78	5.14	0.77	-0.81	-0.85	-0.61	-0.04
Finance and Business Services	1.01	1.04	0.83	0.61	9.55	9.74	7.58	5.76	-1.02	-1.05	-0.84	-0.62
Public Admin. and Education	0.30	0.33	0.08	-0.25	2.88	3.07	0.56	-1.97	-0.30	-0.34	-0.08	0.26
Other Services	0.95	0.99	0.73	0.41	9.20	9.42	6.76	4.07	-0.96	-1.00	-0.75	-0.41

7.5.2 Changes of Production Prices in Sectors

There are three different prices related to production activity, namely, output price of activity (PA), value-added price (PVA) and price of aggregate intermediate input ($PINTA$). In the CGE-ILA model, the base values for activity price and value added price are set as 1, but price of aggregate intermediate input is not equal to 1 because the intermediate input includes domestic and imported goods. The simulation results which show the impacts of 1% increase of immigration labour on the change of these three prices are reported in Tables 7.21, 7.22 and 7.23, respectively. Moreover, the percentage changes in prices of composite goods (PQ) are shown in Table 7.24.

According to the equation of activity revenue and costs function (equation 8), activity price times activity level equal to value-added price times quantity of value-added plus aggregate intermediate input price times quantity of intermediate input. On the one hand, highly-skilled, skilled and semi-skilled labour immigration would all increase the activity price of Primary and Secondary Industries. The activity price of Construction sector has the most obvious increase from 0.14% to 0.59% by 1% increase in higher-skilled labour immigration, while Manufacturing sector only has very slightly change at about 0.002%. On the other hand, highly-skilled, skilled and semi-skilled labour immigration would have negative effects on activity price of most Tertiary Industries. Highly-skilled and skilled labour immigration have the largest negative effects on Public Administration and Education, but the smallest negative effects on Finance and Business Services by -0.01% and on Distribution and Hotel by -0.02%, separately. Highly-skilled labour immigration scenario is the only one that could cause a reduction of activity price in Finance and Business Services. Semi-skilled labour immigration has the negative effects on activity price of almost all Tertiary Industries except Finance and Business Services.

Compared with former three skilled types of labour immigration, unskilled labour immigration would mainly cause the reduction of activity price in the Primary and Secondary Industries that Manufacturing and Construction reduced by about 0.02% and Agriculture by 0.002%. Distribution and Hotel and Transport and Communication, which employ the most unskilled labour among all sectors of Tertiary Industry, also have the reduction on their activity prices. Simulation results of all skill types labour immigration (column A5 and B5) also show a significant reduction in the Tertiary Industries, but an increase in the most sectors of Primary and Secondary Industries.

Overall view, the activity price of Energy and Water supply increased in all scenarios, while the price of Distribution and Hotel decreased. This may indicate that: (1) an increase of higher-skilled labour immigration will result an increase in the prices of utility and natural resources based products, but a decrease in the prices of the capital-intensive and labour-intensive sectors; (2) an increase of lower-skilled labour immigration will result an increase in the prices of utility-based sectors (i.e., Energy and Water Supply sector) and capital-intensive and labour-intensive sectors (all service sectors), but a decrease in the prices of Agriculture, Manufacturing, Construction and Transport and Communication sectors.

Table 7.22 shows the percentage changes in value-added prices across sectors by the labour immigration scenarios. Value-added price is calculated by value-added divided by activity quantity. The results show that the pattern of changes of value-added price is almost similar with that of activity price. However, there are some differences: 1) 1% increase in highly-skilled and skilled labour immigration would reduce the value-added price of Manufacturing by about -0.01%, which did not happen in the change of activity price. This may indicate that a unit of higher-skilled labour brings larger value-added than a unit of lower-skilled labour does. Thus, higher-skilled labours are profitable production factor under the current structure of UK economy. 2) By a close look at the

impact of scenario A4, it can be seen that apart from utility and public service (Finance and Business Services and Public Administration and Education) sectors, lower-skilled immigration labour had also made a positive contribution towards the value-added prices in all other sectors; although its impact on value-added price was relatively small in percentage change, compared with highly-skilled immigration labour. This may illustrate that all types of immigration labour make positive contribution toward value-added price.

As the price of aggregate intermediate input (*PINTA*) is the main source of activity price (*PA*), it is not surprising to see that the change pattern of *PINTA* was almost similar with that of *PA*.

Table 7.24 displays the percentage changes of composite commodity price (*PQ*) across sectors by the labour immigration scenarios. Composite commodity price is defined as the market price paid by domestic commodity demanders, including sales tax and transaction costs. Due to the government subsidy on Agriculture, the base values of *PQ* show that only *PQ* of Agriculture is less than 1, others are all larger than 1. Compared with the results of output price of activity in Table 7.21, the trend of percentage changes of *PQ* in each sector are almost the same as the change of activity price. Moreover, the effects of labour immigration on *PQ* are smaller than on activity price.

To sum up:

- 1) An increase of labour immigration will result an increase in the prices of the utility and natural resources based products.
- 2) An increase of highly-skilled labour result a decrease in the prices of products produced by the sectors with the capital-intensive and/or higher-skilled labour-intensive sectors.

- 3) An increase of unskilled labour lead to an increase in the prices of capital-intensive and labour-intensive sectors (all service sectors), and a decrease in the prices of Agriculture, Manufacturing, Construction and Transport and Communication sectors.
- 4) A unit of higher-skilled labour brings larger value-added than a unit of lower-skilled labour does. Thus, higher-skilled labours are more productive, and thus more profitable under the current structure of UK economy.
- 5) Lower-skilled immigration labour had also made a positive contribution towards the value-added prices in all other sectors; although its impact on value-added price was relatively small in percentage change, compared with highly-skilled immigration labour.
- 6) All types of immigration labour make positive contribution toward value-added price.

Table 7.21 The percentage changes in output prices of activities (PA)

Sectors	Base value	Scenarios' results: percentage deviations from base value ($\Delta\%$)														
		A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
Agriculture	1	0.12	0.06	0.002	-0.002	0.18	1.11	0.59	0.01	-0.02	1.66	-0.12	-0.06	0.00	0.00	-0.19
Energy and Water supply	1	0.06	0.03	0.02	0.02	0.13	0.57	0.31	0.15	0.16	1.15	-0.06	-0.03	-0.02	-0.02	-0.14
Manufacturing	1	0.002	0.002	0.003	-0.02	-0.01	0.02	0.02	0.03	-0.16	-0.11	0.00	0.00	0.00	0.02	0.01
Construction	1	0.59	0.32	0.14	-0.02	1.03	5.49	2.99	1.23	-0.21	9.36	-0.60	-0.33	-0.15	0.02	-1.05
Distribution and Hotel	1	-0.05	-0.02	-0.06	-0.01	-0.14	-0.48	-0.14	-0.55	-0.06	-1.24	0.05	0.02	0.07	0.01	0.14
Transport and Communication	1	0.02	0.002	-0.02	-0.02	-0.01	0.21	0.02	-0.18	-0.15	-0.08	-0.02	0.00	0.02	0.02	0.01
Finance and Business Services	1	-0.01	0.01	0.03	0.03	0.04	-0.13	0.05	0.23	0.23	0.37	0.01	-0.01	-0.03	-0.03	-0.05
Public Admin. and Education	1	-0.25	-0.16	-0.05	0.001	-0.46	-2.34	-1.43	-0.48	0.01	-4.14	0.26	0.16	0.06	0.00	0.47
Other Services	1	-0.09	-0.08	-0.05	0.003	-0.21	-0.84	-0.76	-0.40	0.03	-1.95	0.09	0.08	0.05	0.00	0.22

Table 7.22 The percentage changes in value added prices (PVA)

Sectors	Base value	Scenarios' results: percentage deviations from base value ($\Delta\%$)														
		A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
Agriculture	1	0.23	0.12	0.00	0.00	0.35	2.13	1.11	0.04	-0.01	3.20	-0.23	-0.12	-0.01	0.00	-0.36
Energy and Water supply	1	0.06	0.03	0.02	0.02	0.14	0.57	0.31	0.14	0.22	1.19	-0.07	-0.03	-0.02	-0.03	-0.14
Manufacturing	1	-0.01	-0.01	0.00	-0.04	-0.06	-0.11	-0.06	0.00	-0.34	-0.51	0.01	0.01	0.00	0.04	0.06
Construction	1	1.05	0.56	0.24	-0.04	1.80	9.78	5.26	2.11	-0.41	16.57	-1.06	-0.57	-0.25	0.05	-1.84
Distribution and Hotel	1	-0.10	-0.03	-0.12	-0.02	-0.27	-0.93	-0.30	-1.08	-0.14	-2.45	0.10	0.03	0.13	0.02	0.28
Transport and Communication	1	0.04	0.00	-0.04	-0.03	-0.03	0.40	0.02	-0.35	-0.30	-0.19	-0.04	0.00	0.04	0.03	0.03
Finance and Business Services	1	-0.03	0.00	0.03	0.03	0.04	-0.29	0.01	0.28	0.30	0.29	0.03	0.00	-0.03	-0.03	-0.04
Public Admin. and Education	1	-0.40	-0.25	-0.09	0.00	-0.73	-3.68	-2.27	-0.77	0.01	-6.54	0.41	0.25	0.09	0.00	0.75
Other Services	1	-0.13	-0.13	-0.08	0.00	-0.33	-1.24	-1.16	-0.66	0.00	-3.02	0.14	0.13	0.08	0.00	0.34

Table 7.23 The percentage changes in prices of aggregate intermediate input (PINTA)

Sectors	Base value	Scenarios' results: percentage deviations from base value ($\Delta\%$)														
		A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
Agriculture	1.06	0.02	0.01	0.00	0.00	0.03	0.20	0.13	-0.01	-0.03	0.27	-0.02	-0.01	0.00	0.00	-0.03
Energy and Water supply	1.05	0.06	0.03	0.02	0.01	0.13	0.56	0.32	0.16	0.11	1.11	-0.06	-0.04	-0.02	-0.01	-0.13
Manufacturing	1.11	0.01	0.01	0.01	0.00	0.02	0.09	0.06	0.04	-0.04	0.15	-0.01	-0.01	-0.01	0.00	-0.02
Construction	1.08	0.29	0.16	0.08	-0.01	0.52	2.74	1.52	0.66	-0.08	4.76	-0.30	-0.17	-0.08	0.01	-0.54
Distribution and Hotel	1.06	0.00	0.00	0.00	0.00	0.01	-0.01	0.03	0.01	0.02	0.05	0.00	0.00	0.00	0.00	-0.01
Transport and Communication	1.05	0.01	0.00	0.00	0.00	0.00	0.05	0.02	-0.03	-0.02	0.02	-0.01	0.00	0.00	0.00	0.00
Finance and Business Services	1.03	0.01	0.01	0.02	0.02	0.05	0.05	0.11	0.16	0.14	0.46	-0.01	-0.01	-0.02	-0.02	-0.05
Public Admin. and Education	1.06	-0.05	-0.03	-0.01	0.00	-0.08	-0.42	-0.25	-0.06	0.01	-0.71	0.05	0.03	0.01	0.00	0.08
Other Services	1.06	-0.04	-0.03	-0.01	0.01	-0.06	-0.34	-0.25	-0.08	0.07	-0.60	0.04	0.03	0.01	-0.01	0.07

Table 7.24 The percentage changes in prices of composite goods (PQ)

Sectors	Base value	Scenarios' results: percentage deviations from base value ($\Delta\%$)														
		A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
Agriculture	0.94	0.10	0.06	0.00	0.00	0.16	0.95	0.51	0.01	-0.02	1.42	-0.11	-0.06	0.00	0.00	-0.16
Energy and Water supply	1.03	0.06	0.03	0.02	0.02	0.13	0.54	0.30	0.15	0.17	1.10	-0.06	-0.03	-0.02	-0.02	-0.13
Manufacturing	1.17	0.00	0.00	0.00	-0.01	-0.01	0.02	0.01	0.03	-0.13	-0.07	0.00	0.00	0.00	0.01	0.01
Construction	1.08	0.60	0.33	0.14	-0.02	1.05	5.61	3.05	1.26	-0.21	9.55	-0.61	-0.33	-0.15	0.02	-1.07
Distribution and Hotel	1.03	-0.06	-0.02	-0.07	-0.01	-0.15	-0.54	-0.17	-0.60	-0.08	-1.39	0.06	0.02	0.07	0.01	0.16
Transport and Communication	1.01	0.02	0.00	-0.02	-0.02	-0.03	0.16	-0.02	-0.21	-0.17	-0.21	-0.02	0.00	0.02	0.02	0.03
Finance and Business Services	1.03	-0.02	0.01	0.03	0.03	0.05	-0.16	0.05	0.25	0.25	0.38	0.02	-0.01	-0.03	-0.03	-0.05
Public Admin. and Education	1.01	-0.26	-0.16	-0.06	0.00	-0.47	-2.37	-1.45	-0.49	0.01	-4.20	0.26	0.16	0.06	0.00	0.48
Other Services	1.07	-0.10	-0.09	-0.05	0.00	-0.24	-0.93	-0.84	-0.45	0.02	-2.18	0.10	0.09	0.05	0.00	0.24

7.5.3 Changes of Production Quantity in Sectors

The first nested CES production function (Equation 11) in the CGE-ILA model describes the relationship among the quantity of domestic activities output (QA), the quantity of value added (QVA) and the quantity of aggregate intermediate input ($QINTA$). Tables 7.25, 7.26 and 7.27 show the percentage changes of QA , QVA and $QINTA$ in all sectors under the different labour immigration scenarios.

Quantity of domestic activities output (QA): The base values of QA in Table 7.25 show that the most productive sector in the UK is Finance and Business Services sector up to £553 billion, followed by Manufacturing sector at about £437 billion and Public Administration and Education sector at about £339 billion, while Agriculture is the least productive sector only reach £25 billion. From results, it can be seen that no matter which labour immigration scenario happens, there is an obvious increase in all sectors' activity output. Comparing with the different skill types of labour immigration, in most sectors, the results show that the higher the skilled labour increase in the UK labour market, the larger the quantity of production will be. For example, in Finance and Business Services sector, 1% increase of highly-skilled immigration labour has positive effect at about 0.29%, which is more than double of effect of skilled immigration labour, and about seven times more than effect of semi-skilled immigration labour, and about thirteen times more than effect of unskilled immigration labour. Therefore, it is undoubted that highly-skilled immigration labour makes the largest contribution to the development of UK economy.

However, there are some exceptions: 1) in Agriculture sector, scenario A4 has larger effect on output at 0.06% than both scenarios A2 and A3 at about 0.05%. As mentioned in Table 7.15, Agriculture sector is an unskilled labour-intensive sector, in which unskilled labour takes about 56% of total employment. The results may indicate that

unskilled labour has larger marginal profit to Agriculture sector than skill and semi-skilled labour. Similarly, in Energy and Water Supply sector and Manufacturing sector, unskilled labour immigration also has larger effects on outputs than semi-skilled labour immigration. 2) In Distribution and Hotel sector, 1% increase in semi-skilled immigration labour has larger effect on output at 0.11% than the effect of the skilled at 0.09%.

Therefore, if the development goals include the strengthening of particular sectors, such as Agriculture and Distribution and Hotel sectors, then, a proportionate amount of lower-skilled immigration labour may be needed.

Quantity of value added (QVA) and quantity of aggregate intermediate input (QINTA): Table 7.26 and Table 7.27 show the following three points:

- 1) Increase of all types of immigration labour has positive effects on the percentage changes of QVA and QINTA, which are the function of QA; but those two tables illustrate the different patterns of growth path. Whilst Table 7.27 demonstrates the impacts on the enlargement of production quantity from exogenous growth, Table 7.26 reveals the impacts on that from endogenous growth.
- 2) By looking at the cross sectors, the contribution of immigration labour to Manufacturing, Distribution and Hotel, Finance and Business Services, Public Administration and Education, and Other Services sectors comes mainly via endogenous path; the contribution to other sectors, such as Agriculture, Energy and Water Supply and Construction sectors, has been achieved largely by exogenous expansion.
- 3) In terms of the contribution by different skill types of immigration labour, the

results present a mixed picture. Nevertheless, the general trend is relatively clear: highly-skilled and skilled labour make contribution to the changes in quantity mainly via endogenous growth model in modern sectors, while the semi-skilled and unskilled labour does it via exogenous growth approach in more traditional sectors.

Table 7.25 The percentage changes in quantity of activities (QA)

Sectors	Base value (Billion)	Scenarios' results: percentage deviations from base value ($\Delta\%$)														
		A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
Agriculture	24.96	0.11	0.05	0.04	0.06	0.27	0.97	0.50	0.40	0.55	2.41	-0.11	-0.05	-0.05	-0.06	-0.27
Energy and Water supply	85.91	0.14	0.07	0.03	0.04	0.27	1.29	0.65	0.23	0.34	2.55	-0.14	-0.07	-0.03	-0.04	-0.28
Manufacturing	436.80	0.27	0.14	0.06	0.11	0.58	2.48	1.29	0.51	1.01	5.29	-0.27	-0.14	-0.06	-0.12	-0.59
Construction	172.02	0.92	0.50	0.24	0.13	1.79	8.41	4.58	2.07	1.16	15.91	-0.94	-0.51	-0.24	-0.13	-1.83
Distribution and Hotel	231.87	0.21	0.09	0.11	0.04	0.45	1.95	0.86	0.98	0.33	4.17	-0.21	-0.09	-0.11	-0.04	-0.46
Transport and Communication	169.79	0.18	0.10	0.07	0.06	0.40	1.63	0.89	0.64	0.50	3.63	-0.18	-0.10	-0.07	-0.06	-0.41
Finance and Business Services	552.57	0.29	0.14	0.04	0.02	0.49	2.66	1.25	0.38	0.20	4.44	-0.29	-0.14	-0.05	-0.02	-0.50
Public Admin. and Education	339.25	0.08	0.04	0.02	0.01	0.15	0.74	0.41	0.15	0.06	1.37	-0.08	-0.04	-0.02	-0.01	-0.15
Other Services	101.38	0.25	0.16	0.08	0.03	0.52	2.32	1.54	0.74	0.24	4.89	-0.25	-0.17	-0.09	-0.03	-0.53

Table 7.26 The percentage changes in quantity of aggregate value-added (QVA)

Sectors	Base value (Billion)	Scenarios' results: percentage deviations from base value ($\Delta\%$)														
		A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
Agriculture	12.03	0.07	0.04	0.04	0.06	0.21	0.67	0.34	0.39	0.54	1.95	-0.07	-0.04	-0.05	-0.06	-0.22
Energy and Water supply	40.24	0.14	0.07	0.03	0.04	0.27	1.29	0.65	0.23	0.32	2.54	-0.14	-0.07	-0.03	-0.04	-0.27
Manufacturing	168.46	0.27	0.14	0.06	0.12	0.59	2.52	1.31	0.52	1.06	5.41	-0.28	-0.14	-0.06	-0.12	-0.60
Construction	67.31	0.79	0.43	0.21	0.14	1.55	7.13	3.89	1.80	1.22	13.71	-0.81	-0.43	-0.21	-0.14	-1.60
Distribution and Hotel	115.94	0.22	0.10	0.13	0.04	0.49	2.09	0.91	1.14	0.35	4.56	-0.23	-0.10	-0.13	-0.04	-0.50
Transport and Communication	79.35	0.17	0.10	0.08	0.06	0.41	1.58	0.89	0.69	0.54	3.67	-0.17	-0.10	-0.08	-0.06	-0.41
Finance and Business Services	294.85	0.29	0.14	0.04	0.02	0.49	2.71	1.27	0.37	0.17	4.46	-0.30	-0.14	-0.04	-0.02	-0.50
Public Admin. and Education	198.94	0.12	0.07	0.03	0.01	0.23	1.16	0.67	0.24	0.06	2.14	-0.13	-0.07	-0.03	-0.01	-0.23
Other Services	55.86	0.26	0.18	0.09	0.03	0.56	2.44	1.67	0.82	0.25	5.23	-0.26	-0.18	-0.10	-0.03	-0.57

Table 7.27 The percentage changes in quantity of aggregate intermediate input (QINTA)

Sectors	Base value (Billion)	Scenarios' results: percentage deviations from base value ($\Delta\%$)														
		A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
Agriculture	12.54	0.14	0.07	0.05	0.06	0.31	1.25	0.63	0.40	0.55	2.83	-0.14	-0.07	-0.05	-0.06	-0.32
Energy and Water supply	42.22	0.14	0.07	0.03	0.04	0.27	1.29	0.64	0.23	0.36	2.56	-0.14	-0.07	-0.03	-0.04	-0.28
Manufacturing	239.00	0.27	0.14	0.06	0.11	0.57	2.46	1.28	0.51	0.97	5.21	-0.27	-0.14	-0.06	-0.11	-0.58
Construction	96.04	1.01	0.55	0.26	0.13	1.94	9.28	5.03	2.24	1.12	17.41	-1.03	-0.56	-0.26	-0.13	-1.99
Distribution and Hotel	103.56	0.19	0.09	0.09	0.03	0.41	1.81	0.81	0.80	0.30	3.77	-0.20	-0.09	-0.09	-0.04	-0.41
Transport and Communication	85.10	0.18	0.10	0.07	0.05	0.40	1.68	0.89	0.59	0.46	3.60	-0.19	-0.10	-0.07	-0.05	-0.40
Finance and Business Services	246.76	0.28	0.13	0.05	0.02	0.49	2.60	1.24	0.40	0.22	4.41	-0.29	-0.14	-0.05	-0.03	-0.50
Public Admin. and Education	131.71	0.02	0.01	0.00	0.01	0.03	0.16	0.05	0.02	0.06	0.31	-0.02	-0.01	0.00	-0.01	-0.03
Other Services	42.04	0.23	0.15	0.07	0.03	0.48	2.17	1.39	0.65	0.23	4.46	-0.23	-0.15	-0.08	-0.03	-0.49

7.6 Sensitivity Analysis

One of the main weaknesses of CGE modelling is the uncertainty about the fitness of key parameter values, e.g. elasticities of production and trade. Mansur and Whalley (1984) believed that the different value of elasticities has significant impacts on the results of CGE model. The value of elasticities which cannot be calibrated directly from the benchmark data were taken from outside literature. Therefore, sensitivity analysis of CGE model usually focuses on assessing the robustness of the results of policy simulations with regard to the choice of elasticity values. This section assesses the sensitivity of the results to the elasticities of substitutions in the four-level CES production functions, and substitutions between domestic goods and imports (Armington) and between domestically sale goods and export (CET).

In fact, sensitivity analysis is examining the robustness of the variables in the model results in the case of key parameters deviating from the base values (Zhao and Wang, 2008). There has been a long history of CGE studies based on Systematic Sensitivity Analysis (SSA) (Pagna and Shannon, 1987; Wigle, 1991; Harrison *et al.*, 1993 and Hertel *et al.*, 2007). Using the random number generator of elasticities in GAMS, Li and Rose (1995) ran 100 simulations to verify that the means of the key aggregate variables from the experiment were close to those obtained with the point estimates. On the same way, Zhao and Wang (2008) ran 500 times of simulation to test the robustness of variables.

In order to explore the sensitivity of elasticities, the Systematic Sensitivity Analysis (SSA) is employed in the current study following the approach of Li and Rose (1995) and Zhao and Wang (2008); and 100 randomized runs of the model by the similar method were undertaken. The elasticities are assumed to be randomly drawn from a uniform distribution, with lower and upper boundaries that correspond to -75% and

+75%, respectively, of the assumed baseline elasticity values. The sensitivity analysis in a larger range of elasticity value will enhance the robustness of the results.

The random number generate program in GAMS is presented as follow:

Execseed = 1 + gmillisec (jnow);

Prodelas1 (A) = uniform (0.1, 1.5);

Prodelas2 (A) = uniform (0.1, 0.5);

Prodelas3 (A) = uniform (0.3, 2.5);

Prodelas4 (A) = uniform (0.5, 3);

Prodelas5 (A) = uniform (0.3, 3);

Tradelas (C, 'SIGMAQ') = uniform (0.5, 3);

Tradelas (C, 'SIGMAT') = uniform (0.5, 3);

Which, 'Execseed' is to generate the seed of random number; 'gmillisec' can be zero, so plus one to guarantee the value of 'Execseed' is positive; 'jnow' is the present time, which ensure each value of elasticities obtained in the random variation within a given range; Prodelas1 is the elasticity between capital and aggregate labour, Prodelas2 is the elasticity between aggregate intermediate input and value added, Prodelas3 is the elasticity between aggregate higher-skilled labour and aggregate lower-skilled labour, Prodelas4 is the elasticity between highly-skilled labour and skilled labour, Prodelas5 is the elasticity between semi-skilled labour and unskilled labour; Tradelas are elasticities of trade (including Armington elasticity 'SIGMAQ' and CET elasticity 'SIGMAT'); and 'uniform' means uniform distribution. The economic indicators, which are GDP, GDP per capita (GDPPC) and Unemployment Rate (UER), are chosen for the sensitivity analysis.

There are 100 simulations testing for the elasticities sensitivity analysis, and the statistic results are displayed in Table 7.28 for sensitivity test on GDP under different labour immigration. The statistical results of sensitivity analysis are concluded by the value of

Average, Standard Deviation, lower and upper limit of 95% confidence interval. The outcomes in Table 7.28 show that the initial simulation results of all economic indexes are all locate within the upper and lower limits of 95% confidence intervals, and the confidence intervals have the same changing direction as the initial results. Furthermore, all initial simulation results of GDP are close to the average value of 100 times of sensitivity analysis.

Figure 7.2 illustrates the changes of GDP under 100 times' simulations of different elasticities. Overall speaking, the changes of GDP are all within a certain range. Through the statistical calculation of these simulation results, it is found that 85% of changes of GDP in scenario A1 are in the range of 0.25% - 0.28%, 83% of changes of GDP in scenario A2 are in the range of 0.13% - 0.145%, 84% of changes of GDP in scenario A3 are in the range of 0.065% - 0.072%, 77% of changes of GDP in scenario A4 are in the range of 0.046% - 0.052%, 79% of changes of GDP in scenario A5 are in the range of 0.5% - 0.55%. The changes of GDP in Group B scenarios are also mainly in a certain range. Therefore, these results prove that the changing directions of GDP are correct in all scenarios.

Table 7.29 shows the statistical results of sensitivity test on GDP per capita under different labour immigration. The initial results of GDP per capita are similar with the average value of 100 times' simulation by different elasticities, and locate within the upper and lower limits of 95% confidence intervals. Figure 7.3 illustrates the changes of GDP per capita under 100 times' simulations of different elasticities. The changes of GDP per capita in scenario A2 are all positive and mainly located in the range of 0.01% -0.02%. However, although the changes of GDP per capita in scenario B2 are mainly positive, there are 32% are negative. Moreover, the results of scenario A5 show mainly in positive effects at 92%, while only 22% of GDP per capita in scenario A5 are positive. Therefore, 1% increase in immigration of skilled labour would definitely

increase the domestic GDP per capita, but 10% increase might not. All types of labour immigration increase in 1% also increase GDP per capita, while increase in 10% most likely to decrease it.

Table 7.30 shows the statistical results of sensitivity test on unemployment rate under different labour immigration. The most initial results of unemployment rate are similar with the average value of 100 times' simulation by different elasticities, and locate within the upper and lower limits of 95% confidence intervals. The result of unemployment rate in A1 (-0.188%) is quite different with the average value (-0.131%), so it is in B2 (0.45%) compared with 1.302%. As shown in Figure 7.4, 71% of simulations prove that highly-skilled labour immigration would cause the decrease of unemployment rate in small scale immigration, but 67% of simulations confirm that it would increase unemployment rate in large scale immigration. The other results all suggest that the other three types of labour immigration would increase the unemployment rate in both small and large scale immigration.

To sum up, the Systematic Sensitivity Analysis test results show that nearly all elasticities estimated by and employed to the current study are quite robust and closely reflect the reality.

Table 7.28 Sensitivity test of elasticities on GDP under different scenarios

	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
Average	0.268	0.138	0.069	0.049	0.523	2.46	1.27	0.60	0.44	4.72	-0.270	-0.139	-0.071	-0.050	-0.534
Standard deviation	0.010	0.005	0.003	0.003	0.019	0.11	0.05	0.03	0.02	0.24	0.011	0.005	0.003	0.003	0.020
Lower limit of 95% confidence interval	0.261	0.135	0.067	0.048	0.511	2.39	1.24	0.58	0.43	4.57	-0.263	-0.136	-0.068	-0.048	-0.521
Upper limit of 95% confidence interval	0.274	0.141	0.070	0.051	0.535	2.52	1.30	0.62	0.46	4.87	-0.278	-0.143	-0.072	-0.052	-0.546
Initial results	0.269	0.139	0.069	0.050	0.527	2.48	1.28	0.61	0.45	4.79	-0.274	-0.141	-0.071	-0.051	-0.539

Table 7.29 Sensitivity test of elasticities on GDP per capita (GDPPC) under different scenarios

	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
Average	0.139	0.013	-0.073	-0.046	0.032	1.16	0.02	-0.81	-0.50	-0.18	-0.143	-0.015	0.071	0.045	-0.044
Standard deviation	0.010	0.005	0.003	0.003	0.019	0.11	0.05	0.03	0.02	0.23	0.010	0.005	0.003	0.003	0.019
Lower limit of 95% confidence interval	0.133	0.010	-0.075	-0.047	0.020	1.09	-0.01	-0.82	-0.52	-0.32	-0.136	-0.012	0.073	0.046	-0.029
Upper limit of 95% confidence interval	0.146	0.016	-0.072	-0.044	0.044	1.22	0.05	-0.79	-0.49	-0.04	-0.150	-0.018	0.069	0.043	-0.056
Initial results	0.141	0.014	-0.073	-0.045	0.036	1.18	0.03	-0.80	-0.50	-0.11	-0.146	-0.016	0.071	0.044	-0.048

Table 7.30 Sensitivity test of elasticities on Unemployment Rate (UER) under different scenarios

	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
Average	-0.13	0.24	2.41	1.32	3.79	1.30	4.54	26.48	14.86	42.77	0.19	-0.20	-2.35	-1.28	-3.70
Standard deviation	0.31	0.15	0.12	0.06	0.51	2.54	1.40	1.33	0.65	5.47	0.31	0.15	0.12	0.06	0.51
Lower limit of 95% confidence interval	-0.32	0.15	2.33	1.28	3.47	-0.29	3.67	25.64	14.45	39.34	0.37	-0.12	-2.27	-1.24	-3.39
Upper limit of 95% confidence interval	0.06	0.33	2.48	1.36	4.11	2.90	5.43	27.31	15.26	46.21	-0.01	-0.29	-2.42	-1.33	-4.01
Initial results	-0.19	0.21	2.38	1.30	3.65	0.45	4.00	26.17	14.71	40.51	0.24	-0.17	-2.32	-1.26	-3.56

Figure 7.2 Sensitivity Analyses of Elasticities (GDP) for Different Scenarios

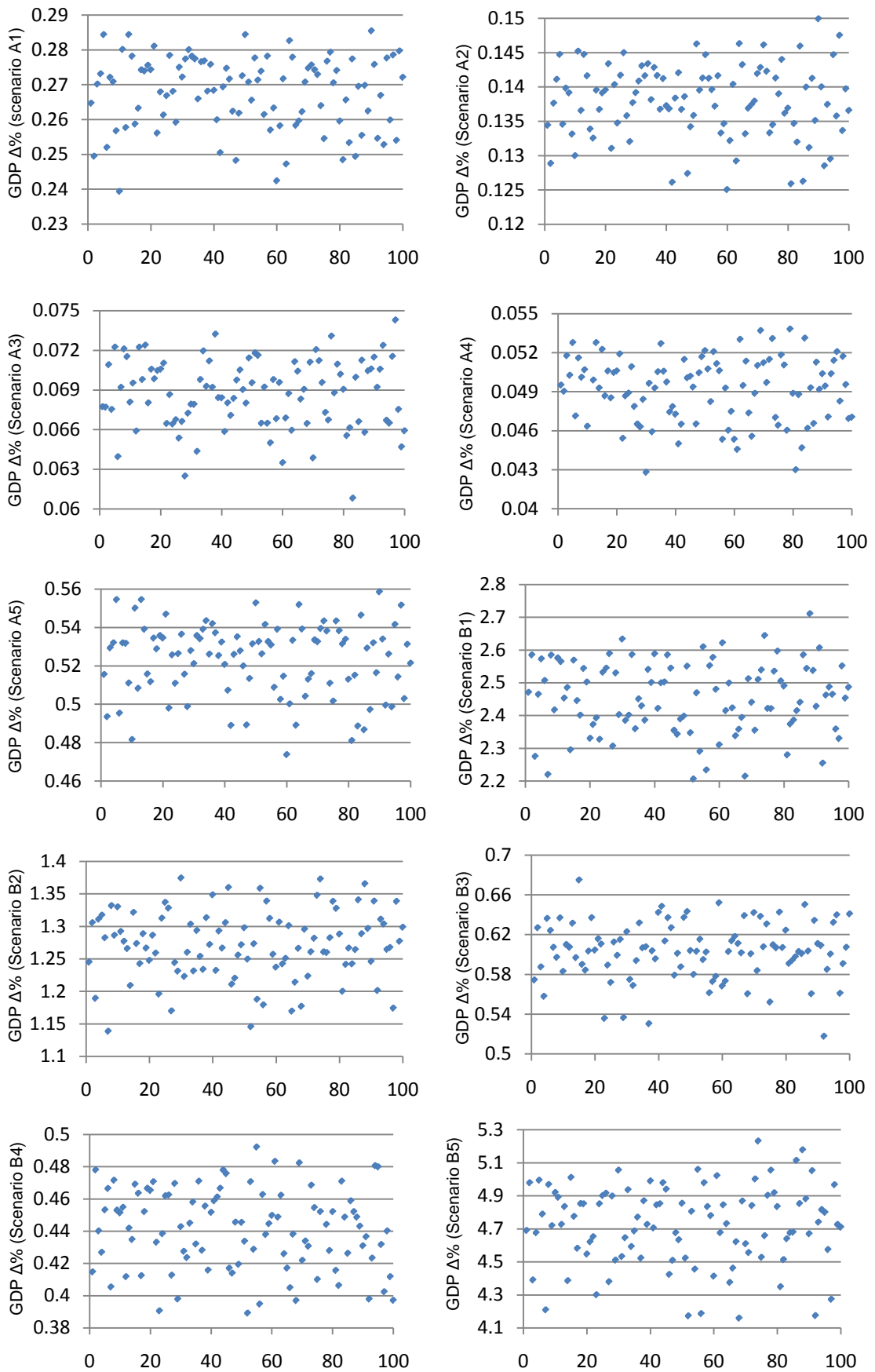


Figure 7.3 Sensitivity Analyses of Elasticities (GDPPC) for Different Scenarios

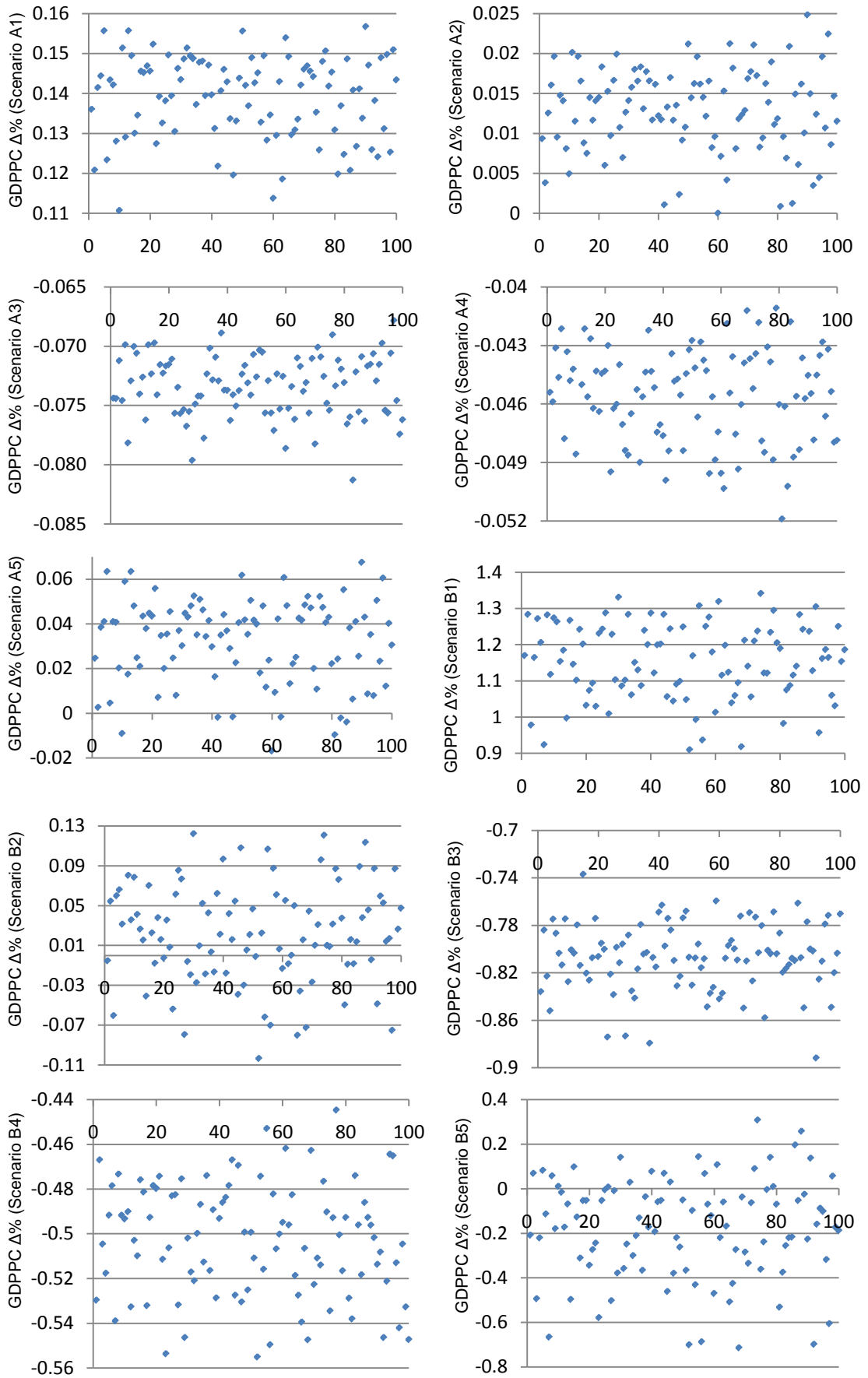
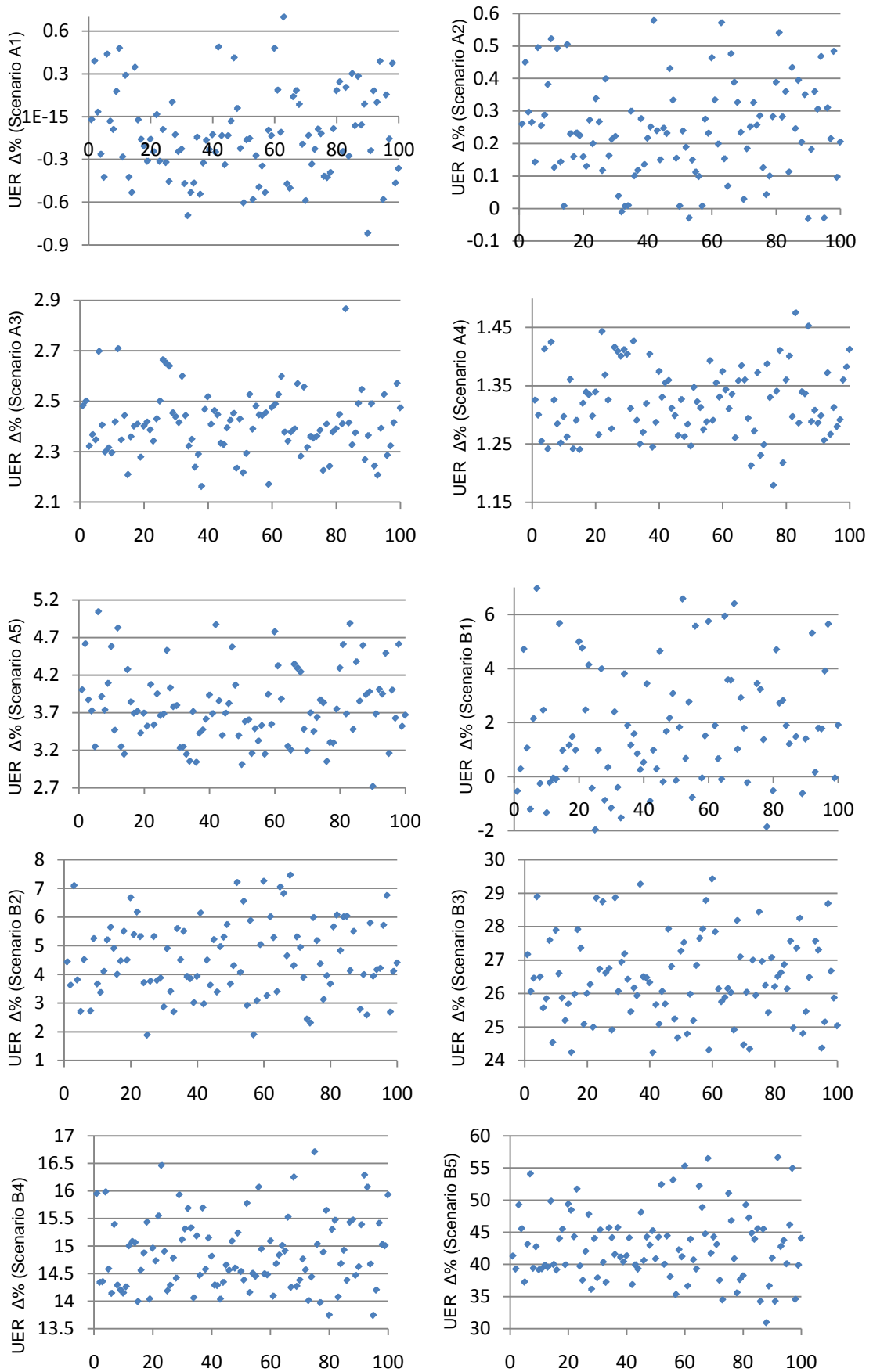


Figure 7.4 Sensitivity Analyses of Elasticities (UER) for Different Scenarios



7.7 Summary

This chapter has presented the simulation results from a Computable General Equilibrium model for immigration labour analysis (CGE-ILA) applied to the UK. There are fifteen scenarios in three groups have been carried out to measure the impacts of different skilled types of immigration labour on UK economy, which is mainly reflected in the macro-economic performance, labour market, domestic institutions and production sectors.

A number of economic indicators have been employed to measure the impacts of immigration labour on UK macro-economic performance. The simulation results reveal that increasing immigration labour has positive effect on UK GDP growth, while the effects of different skilled types of labour immigration are varied largely that the higher the skill of immigration labour is expected to bring about higher real GDP growth. In terms of GDP per capita, the results show that highly-skilled and skilled immigration labours have positive effects, and the former effect is much significant; while semi-skilled and unskilled immigration labours have negative effects, and the semi-skilled would worsen more. The results of impacts on CPI show that higher-skilled immigration labour could result in larger deflationary pressures on UK economy.

Similar with the effects on GDP, immigration labour also has the positive effects on private consumption and fixed investment, and increases more in fixed investment. The impacts on international trade reveal that immigration labour promotes more trade between the UK and foreign countries, but only unskilled immigration labour has larger effects on exports than on imports, and also exports more to ROE than to ROW.

The increasing number of international immigration labour has directly effects on UK labour market. Highly-skilled or skilled immigration labour has negative effects on the wages of both, but has positive effects on semi-skilled and unskilled labour. Semi-

skilled immigration labour only has the negative effect on wage of itself, and unskilled immigration labour reduces the wages of semi-skilled and unskilled labour.

Using 'wage curve' theory, the results of immigration labour on unemployment rate show an opposite relationship with wages. The results prove that a specific type of immigration labour would stimulate the competition in labour market, and then cause the decrease of wage and increase of unemployment on relative labour. On the contrary, it has the positive effects on the wage and employment of the complementary labour. The results also find that only highly-skilled immigration labour in small scale can reduce the total unemployment rate, but in large scale also increases the total unemployment rate.

Immigration labour has positive effects on the incomes of all institutions. Among the household groups, HH2 and HH3 seem to get larger benefits than HH1 and HH5 are. Moreover, the great income benefit from immigration labour goes to enterprises; government also receives second largest benefit. In terms of the contribution made by different types of immigration labour, highly-skilled labour is at the top of the rank followed by skilled, semi-skilled and unskilled labour force.

The impacts of immigration labour on production sectors are mainly reflected on three parts, namely, labour demand, prices and quantities of outputs. In terms of labour demand, increasing (reducing) the specified skill level of labour supply by immigration labour would encourage the employment of this type of labour force in all sectors, due to the reduction (increase) of wages. There exists a competitive relationship between highly-skilled and skilled labours, and between semi-skilled and unskilled labours. In the meantime, there seems also exist a complementary relation between higher-skilled and lower-skilled.

In production prices part, highly-skilled, skilled and semi-skilled immigration labour

have negative effects on the activity prices of most Tertiary Industries, but increase the activity prices of all Primary and Secondary Industries. On the contrary, unskilled immigration labour seems more likely to reduce the prices of Primary and Secondary Industries except sector of Energy and Water supply. It is summarised that higher-skilled immigration labour would bring down the prices of skill-intensive sectors, while lower-skilled immigration labour has the reverse effects.

In the production output part, all immigration labours have positive effects on all sectors' output. Almost all sectors follow the common rule that the higher the skill of immigration labour, the larger amount of quantity of products will be produced. However, unskilled immigration labour has the larger effect on production quantities of Primary Industries and Manufacturing sector than semi-skilled immigration labour.

Finally, using Systematic Sensitivity Analysis, 100 randomized runs of the model were undertaken to assess the sensitivity of the results to the elasticities of substitutions among different skill types of labour and substitutions of trade between domestic and foreign regions. The results show that the findings of scenarios are robust to the elasticities.

Chapter Eight:

Conclusions

It is evident that interest in and scope of the international immigration to the developed countries has increased over the last two decades. In order to form the appropriate immigration and labour policies, research is desperately need for industrialised countries to find out the economic consequences under the trends of current international immigration. It has been largely recognised that the UK has been a net immigration country since early 1990s, and the number of annual net immigrants increased steadily from none in 1993 to about 150,000 in 2003, and to 200,000 in 2008, which is largely due to the enlargement of EU occurred in 2004 (Migration Watch UK, 2009).

Consequently, the net increase of immigrants to the UK has caused a wide concern with mixed feelings among the society. While it fills the gap of labour shortage, it might also cause some adverse consequences, such as intense competition in labour market, lower labour wage and increasing unemployment rate. There are huge different opinions between the government and the House and between the enterprises and the public; there is also controversial policy issues between immigration and labour market, and between growth and social welfare. Thus, it is the high time to have a detailed study about the issues. There are quite a lot of empirical studies focusing on the impacts of international immigration on receiving countries, but very limited literature exists for studying the UK cases. Therefore, this study intends to fulfil this gap.

8.1 Main Findings of This Study

Under the neoclassical theory and the Computable General Equilibrium (CGE)

framework, the CGE-ILA model has been constructed for analysing the economic impact of immigration labour force on UK economy by four skill-based groups. A Social Accounting Matrix (SAM), which services as a database for CGE modelling, has also been formulated by using UK Input-Output (I-O) table for 2004, UK National Account Blue Book 2006, International Labour Organisation (ILO) for UK 2004 and the Annual Survey of Hours and Earnings (ASHE) for 2004.

The modelling results have been generated by scenario analysis combining four skill types of immigration labour to look at its impacts on GDP growth, international trade, wage and unemployment, incomes of institutions, employment in sectors, production prices and scale of production. The main findings are as the follows:

8.1.1 On Macro-Economic Performance

GDP: The increase of highly-skilled immigration labour yields the largest increase on the growth of UK real GDP, which is about double of skilled immigration labour, nearly four times of the semi-skilled and more than five times of the unskilled (refer to Table 7.2). Thus, the results indicate that the higher the skill of immigration labour occurred, the higher the real GDP growth brought by immigration labour to UK economy will be expected.

GDP per capita: The effect on GDP per capita seems a more appropriate for assessing the impact of immigration on welfare. The results show that the highly-skilled has significant positive effect by 0.14%, which is about ten times of the skilled. However, the semi-skilled and the unskilled have the adverse effect on GDP per capita by -0.07% and -0.05% (refer to Table 7.2A). Contrast to the effects on real GDP, these results explicitly illustrate that it is the higher-skilled (not any kind of) labour which makes contribution to UK economy in the long-term view.

CPI: The immigration labour seems to have negative effects on CPI. 1% increase of immigration labour force will result a 0.06% decrease of CPI in general. Considering the skill types, the impact ranges from -0.03% (highly-skilled) to -0.003% (unskilled).

International Trade: The overall results show that immigration labour as the whole has the positive effects on both exports and imports either with ROE or with ROW, and the higher the skill of immigration labour force have, the larger the impacts on international trade they make.

- 1) Unskilled immigration labour has larger effects on total exports than semi-skilled has (about 40% more, refer to Table 7.5).
- 2) Considering the effects on ROW and ROE, increase of unskilled immigration labour has larger effect on exports to ROE, while increase of other three skill types has larger effects on export to ROW.
- 3) The immigration labour will have larger impact on stimulating imports than promoting exports, only scenario A4 shows an opposite effects; this might cause a slight worrying of worsening in the balance of payment (BoP).

8.1.2 On Labour Market

Wage: The results show that increase supply of a specified skilled labour by immigration would undoubtedly reduce the wages of domestic similar skill levels of labour, while increase the wages of complementary (down grade) labours (refer to Table 7.6). This is due to the intensified job competition within the group and the complementary relationship between the higher-skilled and lower-skilled, i.e. the larger the gap between skill-levels of labour groups, the greater the complementary than the competition impact it will be.

Another conclusive point can be drawn is that higher-skilled labour inflow will lessen

wage inequality among different skill types of labours; lower-skilled immigration labour will increase the wages of the higher-skilled group, but worsen the wage of lower-skilled group, hence to further enlarge the gap of social wages (refer to section 7.3.1).

Unemployment: One of the important features of CGE-ILA model is the introduction of unemployment equation into the modelling estimation, based on the ‘wage curve’ theory, to capture the imperfect labour market situation.

- 1) The simulation results show that the increasing of one skill type of immigration labour will result an increase of unemployment within the same group, and a decrease of unemployment in other groups.
- 2) The most important insight is that the highly-skilled immigration labour is the only one which could bring positive impacts on reducing unemployment currently; an increase of the supply of the highly-skilled will reduce the total unemployment; the marginal effects reaches the peak at 4% of increase the supply, and the optimal point is found at the point of 8%, indicating the upper limit of the highly-skilled labour inflow into the UK. This means that under the current UK economic structure, highly-skilled labour force is still in short; an increase of 4-8% of highly skilled immigration labour will be very helpful to the UK for reducing unemployment.
- 3) Other three types of immigration labour all play a negative role in reducing the domestic unemployment. Surprisingly, the unskilled immigration labour group has a smaller negative impact on the UK labour market than semi-skilled does. Under a unit increase of immigration labour, the negative impact of unskilled labour is about half of that of semi-skilled labour.
- 4) The increase of semi-skilled immigration labour will lead to the most significant increase in the total unemployment among all skill types of immigration labour. This means that semi-skilled labour force is the least needed in the UK labour market, if the reduction of unemployment is the prior consideration.

8.1.3 On Incomes of Institution

Incomes: Increasing of immigration labour has positive effects on the incomes of all institutions, including households, enterprises and government.

- 1) Among all institutions, the great income benefit from immigration labour goes to enterprises (1.06% increase); the government also receives second largest benefit (0.59% increase); and households benefit vary from one group to another (from 0.17% to 0.32%, refer to Table 7.12A). Among the household groups, HH2 and HH3 seem to get larger benefits than HH1 and HH5 are.
- 2) The contribution made by the highly-skilled is about five times (0.54 : 0.10) as higher as that of the unskilled to enterprises, about six times (0.31 : 0.05) to government, and about five times to households. This implies that the higher the skill of labour force, the larger the contribution they make.
- 3) The unskilled seems to make a larger contribution to lowest income group (HH1) than the semi-skilled (0.02 : 0.01, refer to Table 7.12A and relevant paragraphs in section 7.4.1).

Expenditure: The results of this study show positive impacts of international immigration labour on increase of households' expenditure (with a scope of 0.17-0.32%) and decrease of government expenditure (by 0.31%). The increase of households' expenditure plays a positive role in stimulating domestic consumption. The effects on government expenditure vary from one skill type to another, the higher the skill of immigration labour has, the larger the effect they will bring.

Welfare: The overall picture of the impacts on domestic households' welfare, in general, a positive with some variations (refers to Section 7.4.2 and Table 7.14A).

- 1) The welfare levels for all households have been improved from £0.17 billion to

£0.58 billion; the high income classes gain more in absolute value than the low income classes.

- 2) Highly-skilled immigration labour generates the largest welfare than other types of labour.
- 3) The higher the skill levels of immigration labour, the larger the contribution to households' welfare they generate.

8.1.4 On Production Sectors

Labour Demand:

- 1) Increasing (reducing) the specified skill level of labour supply by immigration labour has positive (negative) effect on the employment of this type of labour force in all sectors, due to the reduction (increase) of wages.
- 2) There exists a competitive relationship between highly-skilled and skilled labours, and between semi-skilled and unskilled labours in some sectors (e.g. Finance and Business Services and Public Administration). There also exists a complementary relation between higher-skilled and lower-skilled in some other sectors (e.g. Energy and Water Supply and Construction).
- 3) Increase of higher-skilled labour is helpful to balance the structure of labour market. On the contrary, increase of lower-skilled labour will worsen the balance of labour market that either semi-skilled or unskilled immigration labour would cause the reduction of employment of other skilled labour force in the majority of sectors, as can be seen in Tables 7.18 and 7.19.
- 4) The direction and scope of the impact also depend on the nature of industrial sectors themselves, such as the specific role played in the national economic system, and the professional knowledge/skills required by a particular sector.
- 5) In general, the increase of immigration labour to the UK labour market is a threat to domestic employees and the labour force in the pool, but it is an

opportunity for employers in different industrial sectors to employ cheap labour force and reduce labour cost.

Production Prices:

- 1) An increase of labour immigration will result an increase in the prices of utility and natural resources based products.
- 2) Highly-skilled labour result a decrease in the prices of the capital-intensive and higher-skilled labour-intensive sectors.
- 3) Unskilled labour lead to an increase in the prices of capital-intensive and labour-intensive sectors (all service sectors), and a decrease in the prices of Agriculture, Manufacturing, Construction and Transport and Communication sectors.
- 4) A unit of higher-skilled labour brings larger value-added than a unit of lower-skilled labour does. Thus, higher-skilled labours are profitable production factor under the current structure of UK economy.
- 5) Lower-skilled immigration labour had also made a positive contribution towards the value-added prices in all other sectors; although its impact on value-added price was relatively small in percentage change, compared with highly-skilled immigration labour.
- 6) All types of immigration labour make positive contribution toward value-added price.

Scale of production: From the scenarios' results, when immigration labours increase, there is an obvious increase in all sectors' activity output.

- 1) The higher the skill of immigration labour increase in the UK labour market, the larger the quantity of production will be.
- 2) Unskilled labour has larger marginal profit to Agriculture sector than skill and semi-skilled labour; so do Energy and Water Supply and Manufacturing sectors, while the semi-skilled has larger effect on output than the skilled does in Distribution and Hotel sector.

- 3) Increase of all types of immigration labour has positive effects on the percentage changes of QVA and QINTA, which are the function of QA; but those two tables illustrate the different patterns of growth path.
- 4) By looking at the cross sectors, the contribution of immigration labour to some sectors (e.g. Manufacturing and Finance and Business Services) comes mainly via endogenous path; the contribution to other sectors (e.g. Agriculture and Construction) has been achieved largely by exogenous expansion.
- 5) Highly-skilled and skilled labour seems to make contribution to the changes in quantity mainly via endogenous growth model in modern sectors, while the semi-skilled and unskilled labour does it via exogenous growth approach in more traditional sectors.

Using Systematic Sensitivity Analysis, 100 randomized runs of the model were undertaken to assess the sensitivity of the results to the elasticities of substitutions among different skill types of labour and substitutions of trade between domestic and foreign. Sensitivity analyses for the elasticities of substitution and transformation show that the results of the counterfactual simulations are relatively robust: although sign changes do occur for variables of GDP per capita and unemployment rate, the mean differences from the initial simulation results are very small.

8.2 Contributions to the Understanding of the Issues

- 1) One of the controversial issues is about assessing how immigration affects the exclusive interests of existing residents in the migrant-receiving country. An obvious approach is to consider the net impacts (i.e., benefits minus costs) on the income and living standards of existing residents. The problem, however, arise as stated in the Chapter One: which criterion(s) should be used for assessing the economic impacts of immigration on the UK, and particularly, whether overall

GDP is a relevant or a misleading criterion?

The results from the current study evident that GDP is an important criterion, but should be used together with other indicators, such as GDP per capita, even better income per capita, CPI, international trade, employment, to capture the overall benefits, as the total size of an economy measured by GDP alone is not an index of prosperity, thus, it is not able to assess the impacts of immigration labour on the welfare of the existing residents.

- 2) What levels and types of immigration labour force are desirable to a receiving country, and whether additional immigration carries benefits or disadvantages? There is no universal but ad hoc answer to these kinds of question. However, the insight obtained from the current study, which is helpful to answer the questions, is that the impacts of immigration depend critically on the skills of immigrants; different types of immigrant can have very different impacts on the economy.

Economic theory tells us that the selecting criterions of skill levels by high-income countries are based on three aspects of the consideration: complementarities with skills and capital of existing residents; long-term growth effects for the host economy; and fiscal effects.

The findings from this study based on the case in the UK provide an evidence to confirm the conclusion of Borjas (1995) study for the US that **admitting high-skilled rather than low-skilled immigration labour would maximise the net gains of existing residents and reduce inequality among workers and ensure that the incomes of the lowest paid are not adversely affected.** A general interpretation of the point is that: in both UK and US labour markets, the elasticity of capital supply is less perfect than people expected; in such a circumstance, the wages of skilled workers are more responsive to supply shifts than the wages of low-skilled workers, partly because skilled workers are more highly complementary to capital than low-skilled workers. A specific explanation for the case in the UK

reflects to its characterised labour market: the relatively higher wage rigidities and higher unemployment, compared with the US.

- 3) Whether immigration generates fiscal benefits to the host country or not is another core issue centred in the debate. The net fiscal impact of immigration is defined as the difference between the taxes that migrants pay and the costs of public services and benefits that they consume.

One of the conclusive points drawn from the current study illustrates that there is a positive impact of immigration on the fiscal benefits; it confirms that the net fiscal impact largely depend on migrants' age structure, earnings, and eligibility for and take-up of government benefits and services; the nature of the welfare system, especially the extent to which it redistributes income from high- to low- income earners. In the case of the UK nowadays, most immigration labour forces are young with relatively small family burdens, their average earnings may be lower but their tax contribution per capita may be higher than that of existing householders. On the other hand, their consumption of social welfare is also low as they have obtained limited eligibility for and take-up of government benefits and services.

Among all skill-types, the highly-skilled migrants make the largest fiscal contribution to the hosting country, as they are employed in high-paid jobs and expected to pay more taxes and be eligible for fewer welfare benefits than low-skilled migrants in low-paid jobs.

- 4) Most of the economic studies in the field focus on supply-side considerations within an aggregate economy; it is interesting and necessary to look at the issues from an angle of labour demand determinants and to critically assess the role immigration can play as a response to staff shortages in particular sectors from the

micro-levels.

By applying a four-category classification of labour force at the production sector levels, the simulation results revealed a mixed picture: despite the superiority the highly-skilled labour has in nearly all aspects of the economy, the unskilled labour can make larger marginal profits than the semi-skilled labour in Agriculture, Energy and Water Supply, and in some of Manufacturing sectors; and the semi-skilled labour can make a greater impacts on output growth than the skilled in Distribution and Hotel sector. A general trend can be described as the following: Highly-skilled and skilled labour make contribution to the changes in quantity mainly via endogenous growth model in modern sectors, while the semi-skilled and unskilled labour does it via exogenous approach in more traditional sectors.

The insight one can obtained here is that for any research in the field, it is not adequate to measure the impacts on macro indicators only, analysis focused at the micro-levels from the demand-side may be equally important as the studies concentrating on the supply-side, as such analysis can, under certain circumstances, provide an economic justification for some quota of low-skilled immigration.

8.3 Methodological Contributions

CGE has been applied in policy studies for a few decades, and it becomes nowadays a mature and standard approach. Within the CGE framework, there is plenty of room of deviation, modification and preparation which are fundamentally important for applying the model to reflect the specific features of the economy under studies.

- 1) In the current study, in order to capture the detail and to answer the questions raised in its objectives, 4-type labour groups, 5-type household classes, and 9-type aggregated production sectors have been introduced into the model. The level of such a detailed classification, so far by our knowledge, is not yet

recorded in the literature of the field. The detailed classifications enable us to look into the micro level of the issues.

- 2) The detailed labour classification requires a corresponding level of CESs for four types of labour. As Figure 5.3 indicates the CES functions are introduced into the model for the substitution relationship not only between capital and labour, but also between and within the higher skilled-labour and the lower-skilled labour.
- 3) Another feature of the current study is to introduce two kinds of outside worlds by taking the rest of Europe (ROE) out from the rest of the world (ROW). This closely reflects the reality that there are two kinds of different relations between the UK and the rest of world. The UK is one of a few important and influential countries within EU, but it is outsider of Economic and Monetary Union (EMU). With those dual identities, the UK has to deal with more complicated relations, such as two exchange rates in the trade with outsides, and boundary control via free labour movement within EU member countries.
- 4) Based on the wage curve theory, the original model has been modified by an imperfect labour market assumption to consider the effects on unemployment. This makes the modelling assumption different from the orthodox version of CGE.

8.4 Policy Implication

As a piece of empirical work, the current study has derived a number of policy implications from its findings; these implications, undoubtedly, should provide the current debate on the immigration with some evidence and insights.

1. The current immigration policy should go ahead.

The overall conclusions from the current study clearly illustrates that immigration labour make the positive contribution on the host country's economy, assessed by either GDP, or GDP per capita, or other indicators such as wages and incomes of lower class households. This indicates that the direction of the current immigration policy is about right and the trend should go continuously forward.

2. A set of indicators, rather than GDP alone, should be used to assess the impact.

Any single indicator has its capacity as well as its limit; so does GDP. It is evident that employing a set of criterion such as GDP, per capita GDP, and per capita income to assess the impacts of immigration labour on the UK economy can provide us with multi-dimension picture to help us to gain better understanding the complicity of the issues.

3. Higher-skilled labour should be the first priority for the UK government to allow them to get into the UK labour market.

Among all-types of immigration labour, higher-skilled labour would make the greatest contribution to GDP growth, and lessen wage inequality among different skill types of labours, and increase the incomes of lower and middle class of household; it is also helpful to reduce the total unemployment rate by creating jobs for semi-skilled and unskilled labour force.

At 4% increase of highly skilled immigration labour, its marginal effect will reach to the peak point: 0.44% of decrease of the domestic unemployment rate; an increase of 4-8% (based on the year 2004's level) will be an optimal policy to the UK for reducing the current unemployment.

4. Some proportion of lower-skilled labour is also demanded by some sectors in

the UK labour market nowadays.

The modelling results show that the unskilled labour can make larger marginal profits than the semi-skilled labour in Agriculture, Energy and Water Supply, and in some of Manufacturing sectors; and the semi-skilled labour can make a greater impacts on output growth than the skilled in Distribution and Hotel sector. This may also be proven by the phenomenon of the existing demand for illegal immigration in the labour market. As discussed previously, there are two different approaches for growth: endogenous and exogenous; and the demand for different skills depends on the growth of sectors. This implies that there is economic justification and empirical rationale of small proportion of lower-skilled immigration labour existing in the UK labour market, although it plays a negative role in reducing unemployment.

5. Capital investment's contribution with a higher-skilled immigration labours is the largest among all types.

This explicitly indicates capital productivity. The results of this study conclude that the higher the skill level of labour force the capital invested into, the larger the contribution of capital to the factor incomes will be.

The policy implication is clear: if the government's major objective is to improve the total factor productivity, **the policy priority is to encourage the inflow of the highly-skilled labour.**

6. The highly-skilled and unskilled immigration labours make a larger contribution to UK International Trade than the skilled and semi-skilled.

The overall impacts of immigration labour are positive on both exports and import either with ROE or with ROW; the highly-skilled immigration labour has an overwhelming superiority on international trade to other three labour groups.

The unskilled immigration labour has larger effects on total exports than semi-skilled has (about 40% more, refer to Table 7.5). Other three all have larger effects

on export to ROW, while the unskilled has larger effect on exports to ROE.

The suggestion to the policy-makers is the same as that made in points 3 and 4 above – favourable to highly-skilled labour

7. The immigration and labour Policies should be even more open towards immigration labour and much strict towards immigration in general.

The net fiscal impact of immigration labour on local (or pre-existing) residents has been a core in the debate, especially between the Government and the House. The core part of the argument is about who counts as an immigrant and what items to include under costs and benefits on which the fiscal impacts are estimated.

To obtain a clear answer, it is necessary to distinguish between the immigration labour (which is more productive) and immigration (which may consist of productive immigration and non-productive immigration). The results from the current study show that the contribution of immigration labour households is largely positive simply because they pay more tax and receive less social security. As this study focuses on immigration labour only, thus, it is beyond our capacity to assess the impact of other types of immigrants such as political or/and economical refugees, asylum seekers and immigration for marriage and family reunion. Nevertheless, one thing is clear: the former is productive with less fiscal burden, but the latter is less productive and more burden.

Thus, in order to make better immigration policy and labour policy, the assessment of immigration labour's impact should be separated from the assessment of overall immigration.

8. Some policies based on a long-term and sustainable consideration of immigration labour are urgently needed.

Given the fact that many public and private enterprises currently rely upon

immigrants, from NHS to City institutions, from construction industry to residential care, it seems to be very difficult, if not impossible, for Britain to be business as usual without existing larger number of immigration labour, at least in the foresee future, as there is very little potential alternative available to increase the local supply currently.

Thus, a set of long-run and consistent policies towards immigration labour, without noises of party politics, should be formed.

9. Quality and availability of immigration data are urgently needed for obtaining a better understanding of the issues.

Lot of confusion and disagreements come from asymmetric information about immigration; lack of related information has been a major obstacle to the in-depth researches in the field; there is a clear and urgent need to improve the quality and availability of the data.

The UK government should make a clear commitment to improving migration statistics and facilitating more comprehensive researches and assessments of the scale, characteristics and impacts of immigration.

8.5 Limitations and Future Research

International labour immigration and its effects on product and factor markets, households and international trade in the current study have been summarised and presented at a rather highly aggregate level by a few parameters, variables and simple functional forms in order to capture the overall picture and general trends of the issues within the UK economy. Obviously, the limitation of the study at the macro-level is not capable to provide the detail. There are number of aspects which can be improved in the further studies in the future.

Firstly, the focus on the impacts of international labour immigration, loosely towards admitting migrants for the primary purpose of employment, means that this study does not address migration questions about asylum-seekers, family re-union, and the admission of migrants for the purpose of study. Although all types of immigration have economic consequence, this study does not find out the suitable data to separate legal immigration labour from all other types.

Secondly, CGE model generally requires a high level of aggregation that may obscure important effects. In this study, the aggregation of local and central governments into a single entity in the model is restrictive. Further disaggregation of these accounts would improve the ability of the model to analyse the fiscal impacts of immigration. The aggregation of the entire foreign countries into two regions (ROE and ROW) is not quite realistic, given the great diversity of countries in that region. The model would be improved if better data could be gathered to calibrate the model, particularly to characterize the economy of developed and developing countries.

Thirdly, CGE-ILA is a static CGE model which cannot forecast the timing of adjustments from benchmark to counterfactual equilibrium. Unlike econometric studies, it is not possible to statistically validate the structure and underlying assumptions of the CGE-ILA model. As the SAM only reflects a 'snapshot' of UK economy in time of 2004 and does not contain detailed time series, which are used in econometric analyses, the direction of effects is more reliable than the magnitude. In addition, in an international model in which migration occurs, a static model cannot capture any additions to human capital that occur over time (perhaps inter-generationally) when a household moves to a country with greater educational opportunity, nor can it capture the timing of the migration from year to year. Therefore, a recursive dynamic CGE model, which essentially links a series of single-period equilibria via the updating of the capital stock, may be considered for future research.

Fourthly, many of the parameters and elasticities are imposed rather than empirically estimated. The most obvious weakness of the CGE-ILA model in terms of data is the lack of reliable estimates of the elasticities of substitution among four different skill types of labour force, especially the elasticities of substitution between domestic and immigration labour. This study carries out sensitivity analyses, which goes a long way to assessing the potential errors from using parameters not acquired through econometric methods.

Fifthly, data constraints have limited the way in which the different income levels of households in the UK have been modelled, for example, no reliable data were available on the income levels of immigration households and the consumption by them. Each of the suggestions for future research put forward in this section will be more demanding in terms of data and thus worsen these constraints so that improving the availability of data on immigration households and its effects on the rest of the economy will be crucial for any progress in the research of international immigration.

Finally, some would see the theoretical supply-side rigour of the model as a weakness. CGE-ILA model typically takes it as axiomatic that firms maximize profits, which implies that they minimise costs. However, in the specific case of energy efficiency, there is a significant and growing literature that focuses on barriers to the adoption of the most efficient energy technologies (Sorrell *et al.*, 2004). The conventional neoclassical behavioural functions of the type assumed here fail to capture some of the significant barriers to the penetration of new technologies. Such barriers include, for example, imperfect information and significant transactions costs that are neglected in the optimisation processes that underlies the functions. Although adjustment costs can be incorporated into CGE models, such models might still privilege market forces as against behavioural ones.

References:

- Agenor, P.R., Fernandes, R., Haddad, E. and Mensbrugghe, D. (2003), 'Analyzing the impact of adjustment policies on the poor: an IMMPA framework for Brazil', the World Bank.
- Ahmed, V. and O'Donoghue, C. (2010) "External shocks in a small open economy: A CGE-Microsimulation analysis", *The Labour Journal of Economics*, Vol.(15) pp.45-90
- Allan, G., Hanley, N., McGregor, P., Swales, K. and Turner, K. (2007) "The impact of increased efficiency in the industrial use of energy: A computable general equilibrium analysis for the United Kingdom", *Energy Economics*, Vol.29, pp.779-798.
- Angrist, J.D. and Kugler, A.D. (2003) Protective or counter-productive? Labour market institutions and the effect of immigration on EU natives? *Economic Journal* 113: F302–F331.
- Appleyard, R. (1999), *Emigration Dynamics in Developing Countries. Volume IV: The Arab Region*. Aldershot (Ashgate), pp. 1-18.
- Armington P.S. (1969) A Theory of Demand for Products Distinguished by Place of Production, Staff Papers-International Monetary Fund, 16 (1): 159-178.
- Arndt, C., Robinson, S., and Tarp, F., (2002) "Parameter estimation for a computable general equilibrium model: a maximum entropy approach". *Economic Modelling*, Vol.19, pp375-398.
- Askari, H. (1974). The contribution of migration to economic growth in the EEC. *Economia Internazionale*, 27, pp.341-345.
- Aydemir, Abdurrahman. (2003), "*Effects of Business Cycles on Labour Market Assimilation of Immigrants*", Ottawa: Statistics Canada.
- Azdan, M.D. (2001), 'Water policy reform in Jakarta, Indonesia: a CGE analysis', The Ohio State University.
- Baas, Timo and Brucker, Herbert, (2008) "Macroeconomic impact of Eastern Enlargement on Germany and UK: Evidence from a CGE model", *Applied Economics Letters*, 1-4, iFirst, Routledge.
- Balaz, V., Williams, A.M., and Kollar, D. (2004) 'Temporary versus permanent youth brain drain: economic implications', *International Migration*, Vol.42 (4), pp.3-34

- Barnes, S., Price, S. and Barriell, M.S. (2008) 'The Elasticity of Substitution: Evidence from a UK Firm-level Data Set', *Bank of England*, Working Paper, No.348.
- Barret, A., Bergin, A. and Duffy, D. (2005) 'The labour market characteristics and labour market impacts of immigrants in Ireland'. *IZA Discussion Paper*, No. 1553.
- Barro, R. and Sala-i-Martin, X., (1992) 'Regional growth and migration: A Japan-United States comparison'. *Journal of the International and Japanese Economies*, **6**, pp.312-346.
- Barro, R.J. and Sala-i-Martin, X., (2004) *Economic Growth*, Second Edition, The MIT Press, Cambridge, Massachusetts, London, England.
- Bednarikova, Z. and Doucha, T., (2009) "The impacts of agricultural policy scenarios on development of remote rural areas – the case study of the Bruntal and Ostrava districts", *Agriculture Economy*, Czech, Vol.4, pp.161-168.
- Berrittella, M., Hoekstra, A.Y., Rehdanz, K. and Roson, R. (2007), 'The economic impact of restricted water supply: a computable general equilibrium analysis', *Water Research*, Vol.41: pp.1799-1813.
- Blanchflower, D.G. and Oswald, A.J. (1995), "An introduction to the Wage Curve", *Journal of Economic Perspectives*, Vol.9, 153-67.
- Blanchflower, D.G. and Shadforth, C. (2007), "Fear, Unemployment and Migration", NBER Working Paper No. 13506.
- Blake, A., Sinclair, M.T. and Sugiyarto, G. (2003) 'Quantifying the impact of foot and mouth disease on tourism and the UK economy' *Tourism Economics*, Vol.9, No.4, pp.449-465.
- Blattner, N. and Sheldon, G. (1989). 'Foreign labour, growth and productivity: The case of Switzerland', in I. Gordon and A.P. Thirwall (eds.), *European factor mobility: Trends and consequences*, MacMillan: London; pp.148-165.
- Bohringer, C. and Loschel, A., (2006). "Computable General Equilibrium Models for Sustainability Impact Assessment: Status quo and Prospects", *Ecological Economics*, Vol. 60, pp. 49-64
- Boeri, T., and Brucker, H. (2005), 'Migration, Co-ordination Failures, and EU Enlargement', *Economic Policy*, Vol.20 (44), pp.629-703.
- Bolt, W. and van Ells, P. J. A. (2000) "Output and inflation in the EU", Staff Reports No. 44, DeNederlandsche Bank.

- Borjas, G. (1986) The demographic determinants of the demand for black labor. In R.B. Freeman and H.J. Holzer (Eds), *The Black Youth Employment Crisis* (pp. 191–230). Chicago, IL: National Bureau of Economic Research, University of Chicago Press.
- Borjas, G. (1987) ‘Immigrants, minorities, and labor market competition’. *Industrial and Labor Relations Review*, Vol.40 (3): pp.382–392.
- Borjas, G. (1995), ‘The Economic Benefits from Immigration’, *Journal of Economic Perspectives*, Vol.9 (2), 322.
- Borjas, George J. (1999a) “The Economic Analysis of Immigration” In O.Ashenfelter and D. Card, eds., *Handbook of Labor Economics*, Amsterdam: North-Holland Elsevier Science, pp. 1697-1760.
- Borjas, George J. (1999b) ‘Heaven’s Door: Immigration Policy and the American Economy’, Published by Princeton University Press
- Borjas, G. (2003) ‘The labor demand curve is downward sloping: re-examining the impact of immigration on the labor market’. *Quarterly Journal of Economics* 118: 1335–1374
- Borjas, G. (2006) ‘The impact of immigration on the labor market’, Paper prepared for the conference of Labour and Capital flows in Europe Following Enlargement, organised by International Monetary Fund, the Joint Vienna Institute, and the National Bank of Poland.
- Borjas, G., Freeman, R.B. and Katz, L.F. (1992) On the labor market effects of immigration and trade. In G. Borjas and R.B. Freeman (Eds), *Immigration and the Work Force: Economic Consequences for the United States and Source Areas* (pp. 213–244). Chicago, IL: National Bureau of Economic Research, University of Chicago Press.
- Bourguignon, F. and Gallais-Hamonno, G. (1977) ‘International labour migrations and economic choices: The European case’. Paris: Organization for Economic Cooperation and Development.
- Bretschger, L. (2001). ‘Labor supply, migration, and long term development’. *Open Economies Review*, Vol.12, pp.5-27.
- Brezis, E. and Krugman, P. (1993), "Immigration, Investment and Real Wages." NBER Working Paper 4563.
- Brochmann, G., (1996), *European Integration and Immigration from Third Countries*. Oslo, Scandinavian University Press.

- Brucker, H. and Kohlhaas, M. (2004) 'International migration to Germany: a CGE analysis of Labour Market Impact'. *Conference Paper, 7th Annual Conference on Global Economic Analysis*, Washington, DC.
- Canova, F. and Ravn, M. (2000). 'The macroeconomic effects of German unification: Real adjustments and the welfare state'. *Review of Economic Dynamics*, Vol.3, pp.423-460.
- Card, D. (1990) 'The impact of the Mariel Boatlift on the Miami labour market', *Industrial and Labour Relations Review*, Vol.43, pp.245-257.
- Card, D. (2001) 'Immigrant inflows, native outflows and the local labor market impacts of higher immigration', *Journal of Labor Economics*, Vol.19 (1): pp.22-64.
- Carneiro, F. G. and Abbache, J. S., (2003) 'The Impacts of Trade on the Brazilian Labor Market: A CGE Model Approach', *World Development*, Vol. 31, No. 9, pp.1581-1595.
- Chang, H. F. (2003) 'Immigration and the Workplace: Immigration Restrictions as Employment Discrimination', 78 CHI.-KENT L. REV. 291, 308-09.
- Chang, H. F. (2007). 'Economic impact of international labor migration: recent estimates and policy implications'. *Temple Political & Civil Rights Law Review*, 16, 321.
- Chen Y.P. (2002), 'Contemporary Issues of American-Hispanic Immigrants and its Impact', *World People*, Vol. 5.
- Ching, H.S. and Chen, L. (2000) 'Links between Emigrants and the Home Country: the Case of Trade between Taiwan and Canada', *Regional Cohesion and Competition in the Age of Globalization*. Cheltenham UK: Edward Elgar pp.185-198.
- Chirinko, R., S. Fazzari and A. Meyer, (2004) 'That elusive elasticity: A long-panel approach to estimating the capital - labour substitution elasticity', CESifo Working Paper 1240, Institute for Economic Research, Munich, Germany.
- Choucri, N. (1999), 'New Perspectives on the Political Economy of Migration in the Middle East', in: Appleyard, R. (ed.), *Emigration Dynamics in Developing Countries. Volume IV: The Arab Region*. Aldershot (Ashgate), pp. 19-43.
- Collado, M.D., Iturbe-Ormaetxe, I., and Valera, G. (2004) 'Quantifying the Impact of Immigration on the Spanish Welfare State', *International Tax and Public Finance*, Vol.11: pp.335-353.
- Collinson Sarah, (1993), *Europe and International Migration*, London and New York: Pinter

Publishers Limited, p.64.

- Coppel J., Dumont, J.C., and Visco, I. (2001) 'Trends in immigration and economic consequences', *OECD Economics Department Working Paper*, p284
- Cury, S., Coelho, A. M and Corseuil, C. H., (2004). "A Computer General Equilibrium Model to Analyze Distributive Aspects in Brazil with a Trade Policy Illustration", *REAL Discussion Papers, No. 04-T-14*. University of Illinois.
- Davies, R. and Rattso, J., (2000). 'Zimbabwe: Economic Adjustment, Income Distribution and Trade Liberalization', *CEPA Working Paper Series 1*, No. 21.
- Davis, D. and Weinstein, D.E. (2002). 'Technological superiority and the losses from migration'. *NBER Working Paper*, No 8971, pp.2-47.
- DeNew, J. and Zimmermann, K. (1994) 'Blue collar labor vulnerability: wage impacts of migration'. In G. Steinmann and R.E. Ulrich (eds), *The Economic Consequences of Immigration to Germany* (pp. 81–99). Heidelberg: Physica.
- Dervis K., de Melo, J., and Robinson, S. (1982) *General Equilibrium Models for Development Policy*. Cambridge University Press, New York.
- Devarajan S., Go D.S., Lewis J.D., Robinson S., Sinko P., (1994), Policy Lessons from a Simple, Open-economy model. Policy Research Working Paper 1375, The World Bank.
- Diewert, W.E. (1971) 'An application of the Shephard duality theorem: a generalized Leontief production function'. *Journal of Political Economy*, 79(3): 481–507.
- Djajic Slobodan,(2001), 'International Migration, Trends, Policies and Economic Impact', New York: Routledge, p.137.
- Drinkwater, S., Paul L., Emanuela L., and Joseph P. (2003): 'The Economic Impact of Migration: A Survey', *FLOWENLA Discussion Papers*, No. 9, HWWA, Hamburg.
- Duignan Peter and Gann L.H. (1998), *The Debate in the United States over Immigration*, California: Stanford University, 1998, P.238.
- Dunlevy, J. and Hutchison, W. (1999). 'The impact of immigration on American import trade in the late nineteenth and early twentieth century'. *Journal of Economic History*, Vol.59 (4), pp.1043-1062.
- Dustmann, C., Fabbri, F., Preston, I. and Wadsworth, J. (2003), 'The local labour market effects of immigration in the UK', Home Office Online Report, 06/03.

- Dustmann C. and Weiss Y. (2007), 'Return Migration: Theory and Empirical Evidence from the UK', *British Journal of industrial relations*, Vol.45 (2): 236-256.
- Engerman Stanley L. and Gallman Robert E., (2000), *The Cambridge Economic History of the United States*, Vol.3: The Twentieth Century, Cambridge University Press, pp.538—539.
- Espinosa, J.A. and Smith, V.K. (1995), 'Measuring the Environmental Consequences of Trade Policy: A Nonmarket CGE Analysis', *American Agricultural Economics Association*, 77, pp.772-777.
- Facchini, G. and Mayda, A.M., (2006). 'Individual Attitudes towards Immigrants: Welfare-state Determinants across Countries', *CEPR Working Paper No.5702*.
- Fakiolas R. (2004) 'The economic effects of migration', *Migration and Political Intervention Theories and Debates*,
- Fei J., Ranis G. (1964). *Development of the Labour Surplus Economy: Theory and Policy*. Homewood, IL: Richard Irwin.
- Felbermayr, G. and Kohler, W. (2007) 'Immigration and native welfare', *International Economic Review*, Vol.48 (3), pp.731-760.
- Feng, S. (2005), 'Water embedded CGE model to assess of the south to north water transfer to recipient region', Paper presented at Proceedings of IFAC2005, Prague, Czech Republic.
- Freeman, R.B. (1982) "Elasticities of Demand for educated labor and elasticities of supply of educated labor", National Bureau of Economic Research, Working Paper, No.1042.
- Friedberg, R. and Hunt, J. (1995) 'The impact of immigrants on host country wages, employment and growth', *Journal of Economic Perspectives*, Vol.9 (2), pp.23-44.
- Girma, S. and Yu, Z. (2002). 'The link between immigration and trade: Evidence from the United Kingdom'. *Weltwirtschaftliches Archiv.*, Vol.138 (1), pp.115-130.
- Global Trade Analysis Project (GTAP) <https://www.gtap.agecon.purdue.edu/>
- Gould, D.M. (1994). 'Immigrant links to the home country: empirical implications for US bilateral trade flows'. *Review of Economics and Statistics*, Vol.76 (2), pp.302-316.
- Glover, S., C. Gott, A. Loizillon, J. Portes, R. Price, S. Spencer, S. Srinivasan and Wills (2001)

- Migration: an economic and social analysis*, London: Home Office, RDS Occasional Paper No. 67.
- Goto, Junichi, (1996), “The Impact of Migrant Workers on the Japanese Economy: Trickle vs. Flood”, New Haven CT: Yale Economic Growth Centre, Yale University.
- Gott, C. and Johnston, K. (2002). The migrant population in the UK: Fiscal effects. Occasional Paper 77, Home Office Research, Development and Statistics.
- Greenaway, D., Reed, G.V. and Winchester, N. (2002) ‘Trade and Rising Wage Inequality in the UK: Results from a CGE Analysis’, Research Paper, Leverhulme Centre for Research on Globalisation and Economic Policy.
- Grossman, Jean Baldwin, (1982) “The Substitutability of Natives and Immigrants in Production”, *The Review of Economics and Statistics*, 64(4), pp596-603
- Gustafsson, B. and Österberg, T. (2001). ‘Immigrants and the public sector budget-accounting’, *Journal of Population Economics*, Vol.14, pp.689-708.
- Hamermesh, D.S. and Grant, J. (1979) “Econometric studies of labor-labor substitution and their implications for policy”, *The Journal of Human Resources*, XIV, 4, pp.518-542.
- Head, K. and Ries, J. (1998), ‘Immigration and trade creation: econometric evidence from Canada’, *The Canadian Journal of Economics*, Vol.31 (1).
- Hanson, G.H. (2008). ‘The economic consequences of the international migration of labour’, NBER Working Paper No.14490, Cambridge, MA.
- Hanson, G.H., Scheve, K. and Slaughter, M.J. (2007). ‘Local Public Finance and Individual Preferences over Globalization Strategies’, *Economics and Politics*, Vol.19: pp.1-33.
- Harrison, G.W., Jones, R., Kimbell, L.J., and Wigle, R., (1993). ‘How robust is applied general equilibrium analysis?’ *Journal of Policy Modeling* Vol.15 (1), pp.99–115.
- Hatton, T. J. (2005). ‘Explaining trends in UK immigration’. *Journal of Population Economics*, Vol.18: pp.719—740
- Hatton, T. J. and Wheatley Price, S. (2005), “Migration, Migrants and Policy in the United Kingdom” in K. F. Zimmermann (ed.) *European Migration: What Do We Know?*, Oxford, Oxford University Press.
- Heijdra, B., Keuschnigg, C. and Kohler, W. (2002) ‘Eastern enlargement of the EU: jobs,

- investment and welfare in present member countries'. *CESifo Working Paper* No. 718.
- Hertel, T., Hummels, D., Ivanic, M. and Keeney, R. (2007) 'How confident can we be of CGE-based assessments of Free Trade Agreements?' *Economic Modelling*, Vol.24, pp.611-635
- Home Office (2006), *A Points-based System: Making Migration Work for Britain*, London
- HOUSE OF LORDS (2008) *The Economic Impact of Immigration*, Report of the Select Committee on Economic Affairs, 1st April, The Stationary Office Ltd: London.
- Hyyia, N. (2010) "Food industry, agriculture and rural economy responding to the efficiency improvements of infrastructure" *International Food and Agribusiness Management Association*, 20th Annual World Symposium, Boston, USA.
- International Organization on Migration (2003), *World Migration 2003. Managing Migration: Challenges and Responses for People On the Move* (Geneva: IOM).
- Itakura, K. (2004), *Applied general equilibrium analysis of the Japan ASEAN free trade agreement*, Purdue University.
- Jaeger, D.A. (1995) 'Skill differences and the effect of immigrants on the wages of natives' US Bureau of Labor Statistics, *Economic Working Paper 273*.
- Johnson, G.E. (1997) 'Changes in Earnings Inequality: The Role of Demand Shifts' *Journal of Economic Perspectives*, Vol.11, pp.41-54.
- Julia-Wise, R., Cooke, S.C., and Holland, D. (2002) 'A Computable General Equilibrium Analysis of a Property Tax Limitation Initiative in Idaho' *Land Economics*, Vol. 78(2), pp207-227.
- Jung, H.S. and Thorbecke, E. (2003), 'The impact of public education expenditure on human capital, growth, and poverty in Tanzania and Zambia: a general equilibrium approach', *Journal of policy modelling*, Vol.25: pp.701-725.
- Keuschnigg, C. and Kohler, W. (2002) Eastern enlargement of the EU: how much is it worth for Austria? *Review of International Economics* 10(2): 324–342.
- Kilkenny, M., (1991). 'Computable General Equilibrium Modelling of Agricultural Policies: Documentation of the 30-Sector FPGE GAMS Model of the United States', USDA ERS Staff Report AGES 9125.
- Kindleberger, C. (1967), *Europe's Postwar Growth: The Role of Labor Supply*, Oxford, Oxford

University Press.

- King, R., Lazarides, G. and Tsardanidis, C. (1999) "Eldorado or Fortress? Migration in Southern Europe". London (Macmillan Publishers)
- Klump, R., McAdam, P. and Willman, A. (2004) "Factor substitution and factor augmenting technical progress in the US: A normalized supply-side system approach" *European Central Bank, Working paper series*, No.367.
- Kohli, U. (1999) 'Trade and migration: a production-theory approach'. In R. Faini, J. de Melo and K.F. Zimmermann (eds), *Migration: The Controversies and the Evidence* (pp. 117–147). Cambridge: Centre for Economic Policy Research.
- Kohli, U. (2002). 'Migration and Foreign Trade: Further Results'. *Journal of Population Economics*, Vol.15: pp.381-387.
- Kremer, M., & S. Watt. 2006. "The Globalization of Household Production." *Working Paper 2008-0086*, Weatherhead Center for International Affairs, Harvard University.
- Krugman, P. (1991). 'Increasing returns and economic geography'. *Journal of Political Economy*, 99, pp.484-499.
- Krusell, P., Ohanian, L.E., Rios-Rull, J.V. and Violante, G.L. (2000) "Capital-skill complementarity and inequality: A macroeconomic analysis", *Econometrica*, Vol.68, No.5, pp.1029-1053.
- Kuster, R., Ellersdorfer, I. and Fahl U. (2007) 'A CGE-Analysis of Energy Policies Considering Labour Market Imperfections and Technology Specifications' Institute of Energy Economics and the Rational Use of Energy, January.
- Lalonde, R.J. and Topel, R.H. (1997) Economic impact of international migration and the economic performance of migrants, *Handbook of Population and Family Economics*, Elsevier Science, Volume 1, Part2, Pages 799-850.
- Leamer, E. (1985) 'Vector auto-regressives for causal inference'. *Carnegie Rochester Conference Series on Public Policy*, 22: 255–304.
- Lee, R.D. and Miller, T. (2000). 'Immigration, Social Security, and Broader Fiscal Impacts', *American Economic Review*, Vol.90, pp.350-354.
- Li and Rose (1995) 'Global warming policy and the Pennsylvania economy: a computable general equilibrium analysis', *Economic Systems Research*, Vol.7, pp.151-171.

- Lisenkova, K., McGregor, P. and Pappas, N. (2007) 'Macroeconomic Impacts of Demographic Change in Scotland: A Computable General Equilibrium Analysis', *IZA Discussion Paper*, No. 2623.
- Li Honggui (1997) International Population Migration and National Policy, *Southern Population*, Vol.3.
- Li Qirong (2007) 'Dual Impacts of International Immigration on Both Sending and Receiving Countries', *Social Science*, Vol.9, pp. 38-49.
- Liu, A. (2008) Contemporary Issues of China's Economy and Finance, course slides, Middlesex University.
- Liu, A. and Greener, R., (1993) Agricultural Policy Analysis in a General Equilibrium Framework: An Introduction to the AGRISM Model for the Philippines. International Development Centre discussion paper, University of Oxford.
- Liu, A., Greener, R. and Yao S., (1996) 'A CGE Model of Agricultural Policy Reform in the Philippines', *Journal of Agricultural Economics*, Vol. 47, Issue 1-4, PP 18-27.
- Liu, A. and Yao S., (2000), 'Policy Analysis in a General Equilibrium Framework', *Journal of Policy Modeling*, Vol. 22, Issue 5, PP 589-610.
- Lofgren, H. (2000). Exercises in General Equilibrium Modelling using GAMS. Microcomputers in policy research 4a. International Food and Policy Institute (IFPRI), Washington D.C.
- Lofgren, H., O. Chulu, O. Sichinga, F. Simtowe, H. Tchale, R. Tseka, & P. Wobst. (2001) 'External Shocks and Domestic Poverty Alleviation: Simulations with a CGE Model of Malawi', *TMD Discussion Paper NO.71*, International Food Policy Research Institute, Washington, D.C., U.S.A.
- Lofgren, H., Harris, R. and Robinson, S. (2002) 'A Standard Computable General Equilibrium (CGE) Model in GAMS' *Trade and Macroeconomics Discussion Paper*, No.75, International Food Policy Research Institute, Washington, D.C.
- Longhi, S., Nijkamp, P. and Poot, J. (2008) 'Meta-Analysis of Empirical Evidence on the Labour Market Impacts of Immigration', *Population Study Centre (PSC) Discussion Papers* No. 67.
- Lu, X., (1997) 'International Migration and Countries' Policies', *Southern Population* (in Chinese), Vol. 3
- Magubu, R. and Chitiga, M., (2007) 'Poverty and Inequality Effects of a High Growth Scenario

- in South Africa: A Dynamic Micro-simulation CGE Analysis', *Stellenbosch Economic Working Papers, No.04*.
- Manacorda, M., Manning, A. and Wadsworth, J. (2010) 'The Impact of Immigration on the Structure of Wages: Theory and Evidence from Britain', *Journal of the European Economic Association*.
- Mansur A. and Whalley J. (1984) Numerical specification of applied general equilibrium models: Estimation, calibration and data, in *Applied general equilibrium analysis*, H. E. Scarf and J. B. Shoven (Editors). Cambridge: Cambridge University Press.
- Massey D.S., (1998) 'Worlds in Motion: Understanding International Migration at the End of the Millennium', Oxford: Clarendon Press.
- McAdam, P. and Willman, A. (2004) 'Production, supply and factor shares: An application to estimating German long-run supply', *Economic Modelling*, 21, 2, pp.191-215.
- Messina A.M. and Lahav G. (2006) *The Migration Reader: Exploring Politics and Policies*, Boulder. London: Lynne Rienner Publishers, 2006, p.111.
- McCloskey, D. (1983), 'The Rhetoric of Economics', *Journal of Economic Literature*, 482-517.
- McDonad, S. and Roberts, D. (1998) 'The Economy-Wide Effects of the BSE Crisis: A CGE Analysis', *Journal of Agricultural Economics*, Vol.49, No.3, Sept. pp458-471.
- McDonald, S. and Punt, C. (2002). Supply constraints, export opportunities and agriculture in the Western Cape of South Africa. *Journal of Studies in Economics and Econometrics* Vol.26 (1):1-18.
- McDonald, I. and R. Solow (1981) 'Wage Bargaining and Employment' *American Economic Review* Vol.71 (5): pp896-908.
- McDonald S. and Thierfelder K. (2009) 'Stage_Lab: An Applied General Equilibrium Model with Enhanced Labour Markets: Technical Documentation', Mimeo. http://www.cgemod.org.uk/stage_lab.pdf
- McKibbin, W.J. and Wilcoxon, P.J. (2004), 'Estimate of the cost of Kyoto: Marrakesh versus the McKibbin-Wilcoxon blueprint', *Energy policy*, Vol.32: 319-346.
- Migration Watch UK (2001), 'History of immigration', accessed on April 2009, http://migrationwatchuk.com/pdfs/History/6_1_History_of_immigration.pdf
- Migration Watch UK (2009) 'Migration Trends 9.24', accessed on April 2009,

<http://www.migrationwatchuk.com/briefingPaper/document/164>

- Mubugu, R. (2005). Introduction to economy-wide environmental economic modelling, Lecture notes: LEK 814. Centre for Environmental Economic and Policy in Africa, University of Pretoria, Pretoria.
- Munk, K.J. (2003) 'Assessment of the introduction of road pricing using a Computable General Equilibrium model', Aarhus University Economics Paper NO. 2005-23.
- OECD, (2001), *Future work on International Migration Following the Renewal of the Mandate of the Working Party on Migration*. Note by the Secretariate, DEELSE/ELSA 7. Paris.
- OECD (2006), *Economic Outlook*, 80, November, Paris.
- ONS, (2009) Office for National Statistics, <http://www.ons.gov.uk/ons/index.html>
- Okkerse L. (2008), 'How to Measure Labour Market Effects of Immigration: A Review', *Journal of Economic Surveys*, Vol. 22, No. 1, pp. 1-30
- Ottaviano, Gianmarco I. P., and Peri, Giovanni. (2005). "Rethinking the gains from immigration: Theory and evidence from the U.S". *NBER Working Paper No. 11672*. Cambridge, MA: National Bureau of Economic Research, October.
- Pagan, A.R., Shannon, J. (1987) 'How reliable are ORANI conclusions'. *Economics Record*, Vol.1, pp.33-45.
- Partridge, M. D. and Rickman D. S. (1998) 'Regional computable general equilibrium modelling: a survey and critical appraisal', *International Regional Science Review* Vol.21, pp.205-248.
- Pauw, K. (2002) "Evaluating the general equilibrium effects of wage subsidy scheme for South Africa", *TIPS Working Paper*
- Peter Duignan and Lewis H. Gann, (1998) *The Debate in the United States over Immigration*, California: Stanford University, P.238.
- Poot, J. and Cochrane, B. (2005). 'Measuring the Economic Impact of Immigration: A Scoping Paper', Population Studies Centre University of Waikato, *Discussion Paper No. 48*.
- Pope, D. and Withers, G. (1993) 'Do migrants rob jobs? Lessons of Australian history, 1861-1991'. *Journal of Economic History* 53(4): pp.719-742

- Pouliakas, K., Roberts, D., Balamou, E. and Psaltopoulos, D. (2008), 'Modelling the Effects of Immigration on Regional Economic Performance and the Wage Distribution: A CGE Analysis of Three EU Regions', *MPRA Paper, No. 14157*.
- Pradhan, B.K., Saluja, M.R. and Singh, S.K., (2006), '*Social Accounting Matrix for India—Concepts, Construction and application's*', SAGE Publications.
- Ripatti, A. and Vilmunen, J. (2001) '*Declining labour share – Evidence of a change in the underlying production technology?*', Bank of Finland Discussion Papers
- Robert E. B. Lucas, (2005) *International Migration and Economic Development*, UK: Edward Elgar, pp.7-8
- Robinson, S., Kilkenny, M. and Hanson, K., (1990). 'USDA/ERS Computable General Equilibrium Model of the United States', Economic Research Service, U.S., Department of Agriculture, Staff Report No. AGES 9049.
- Robinson, S., and M. El-Said, (1997), 'Estimating a Social Accounting Matrix Using Entropy Difference Methods', MERRISA project workshop paper, Harare (Zimbabwe): MERRISA.
- Robinson, S., A. Cattaneo and M. El-Said (2000), 'Updating and Estimating a Social Accounting Matrix Using Cross Entropy Methods', *TMD Discussion Paper Series*, No.58, Washington, D.C.: International Food Policy Research Institute.
- Rosenthal, S.S. and Strange, W.C. (2001) 'The determinants of agglomeration', *Journal of Urban Economics*, Vol.50, pp.191–229.
- Rutten, M., Blake, A. and Reed, G. (2006) 'The Economic Impact of Health Care Provision: A General Equilibrium Assessment of Some Policy Options in the UK's NHS', *Research Paper*, Nottingham University, Leverhulme Centre.
- Sadoulet, E., and de Janvry, A. (1995) 'Quantitative Development Policy Analysis', Baltimore and London: The Johns Hopkins University Press.
- Sarris, A.H. and Zografakis, S. (1999) A computable general equilibrium assessment of the impact of illegal immigration in the Greek economy. *Journal of Population Economics* 12: 155–182.
- Savard, L. (2005) 'Poverty and inequality analysis with a CGE framework: a comparative analysis of the representative agent and micro-simulation approaches', *Development Policy Review*, Vol.23 (3), pp.313-331.

- Schiff, M. (1998) 'Trade, migration and welfare: The impact of social capital'. Mimeo, Development Economics department, The World Bank.
- Shan, J., Morris, A. and Sun, F. (1999) Immigration and unemployment: new evidence from Australia and New Zealand. *International Review of Applied Economics* 13(2): 253–260.
- Shaw, C (2006), '2004-based national population projections for the UK and constituent countries', *Population Trends*, No.123, Spring, Office for National Statistics.
- Shoven, J.B. and Whalley, J. (1984) 'Applied general equilibrium models of taxation and international trade: an introduction and survey'. *Journal of Economic Literature*, Vol.22: pp.1007–1051.
- Shoven, J.B. and Whalley, J. (1992), *Applying General Equilibrium*, Cambridge University Press.
- Sinn, Hans-Werner. (2002). 'EU Enlargement and the Future of the Welfare State'. *Scottish Journal of Political Economy*, Vol.49 (1).
- Smith, J.P. and Edmonston, B. (1997). *The New Americans: Economic, Demographic, and Fiscal Effects of Immigration*. Washington, DC: National Academy Press.
- Solow, Robert, (1956) 'A Contribution to the Theory of Economic Growth', *Quarterly Journal of Economics*, February, Vol.70, pp.65-94
- Solow, Robert, (1979) "Another possible source of wage stickiness", *Journal of Macroeconomics* Vol.1, pp79-82.
- Sorrell, S., O'Malley, E., Schleich, J., Scott, S., (2004). 'The Economics of Energy Efficiency: Barriers to Cost-effective Investment'. Edward Elgar, Cheltenham.
- Spencer, S., Ruhs, M., Anderson, B. and Rogaly B. (2007), *Migrants' lives beyond the workplace: The experiences of East and Central Europeans in the UK*, Joseph Rowntree Foundation, London
- Steineck, A. (1996). 'The factor market effects of immigration'. In S. Gazioglu (ed), *Migrants in the European Labour Market*, pp.1-30.
- Steininger, K.W., Friedl, B. and Gebetsroither, B. (2007), 'Sustainability impacts of car road pricing: a computable general equilibrium analysis for Austria', *Ecological economics*, Vol.63 (1): pp.59-69.

- Susan Thieme (2006), 'Social Networks and Migration: Far West Nepalese Labour Migrants in Delhi'. Münster: pp. 36-40.
- Taylor, A. (1997). 'Peopling the Pampa: On the impact of mass migration to the River Plate, 1870-1914'. *Explorations in Economic History*, Vol.34, 100-132.
- Thissen M. and Lensink, R. (2001), 'Macroeconomic effects of currency devaluation in Egypt: an analysis with a computable equilibrium model with financial markets and forward-looking expectations', *Journal of Policy Modelling*, Vol.23 (4).
- Turner Andrew, (2003) Westminster Hall Sitting *Debate*, 19 March 2003, vol 401 cc270-94WH
- United Nations, (2005) 'World Summit Outcome', Sixtieth session, A/RES/60/1, October.
- UNDP (United Nations Development Program), (2009). *Overcoming Barriers: Human Mobility and Development*. United Nations Development Program, New York.
- Wagner, D., Head, K. and Rias, J. (2002). 'Immigration and the trade of provinces'. *Scottish Journal of Political Economy*, Vol.49 (5), pp.507-525.
- Walmsley, T.L. and Winters, A.L. (2003), 'Relaxing the restrictions on the temporary movement of natural persons: a simulation analysis', London: Centre for Economic Policy Research.
- Wattanukuljarus, A. (2006), 'The nationwide economic and environmental impacts of tourism: a computable general equilibrium approach for Thailand', The University of Wisconsin.
- Wellish, D. and Walz, U. (1999). 'Why do rich countries prefer free trade over free migration? The role of the modern Welfare State' *European Economic review*, 42, pp1595-1612.
- Welsch, H. (2007) 'Armington elasticities for energy policy modelling: evidence from four European countries' *Energy Economics*, Vol.30, pp.2252-2264.
- Weyerbrock, S. (1995) 'Can the European community absorb more immigrants? A general equilibrium analysis of the labor market and macroeconomic effects of East-West migration in Europe'. *Journal of Policy Modeling* 17(2): 85-120.
- Wigle, R., (1991), 'The Pagan-Shannon Approximation: unconditional systematic sensitivity in minutes'. *Empirical Economics*, Vol.16, pp.35-49.
- Williamson, J.G. (1990) *Coping with City Growth during the British Industrial Revolution*. Cambridge: Cambridge University Press.

-
- Withers, G. and Pope, D. (1985) 'Immigration and unemployment'. *Economic Record* Vol.61: pp.554-563.
- Xia Lixian, (1992), 'International Immigration and Latin America', *The Research of Latin America*, Vol.3
- Xie, J. and Saltzman, S. (2000), 'Environmental policy analysis: an environmental computable general equilibrium approach for developing countries', *Journal of Policy Modeling*, Vol.22 (4): pp.453-489.
- Zhao, Y. and Wang, J. (2008) *CGE Model and Its Applications in Economic Analysis*, China Economic Publishing House.
- Zheng, Yuxin and Fan, Mingtai, (2009) *The CGE Model and Political Analysis for China*, Chinese Version, Beijing, Social Sciences Academic Press.
- Zhou Yu'e and BaiQingzhe (2006) 'International Migration and Contemporary International Security: Conflict, Interaction and Challenge', *Around Southeast Asia*, Vol.1
- Zimmermann, K. (1995), "The European migration problem", *Journal of Economic Perspectives*, Vol. 9(2), pp. 45-68
- Zweig David and Chen Changgui, (1995) *China's Brain Drain to the United States*, Berkeley, California: University of California, p.7.

Appendix:

Appendix 1: Sets, Parameters and Variables

1 Sets

$a \in A$	a set of activities,
$a \in ACES(\subset A)$	a set of activities with a CES function at the top of the technology nest,
$a \in ALEO(\subset A)$	a set of activities with a Leontief function at the top of the technology nest,
$c \in C$	a set of commodities (also referred to as c' and C'),
$c \in CD (\subset C)$	a set of commodities with domestic sales of domestic output,
$c \in CDN (\subset C)$	commodities without domestic market sales of domestic output (complement of CD).
$c \in CE (\subset C)$	a set of exported commodities (with domestic production),
$c \in CEN (\subset C)$	non-exported commodities (complement of CE),
$c \in CM (\subset C)$	a set of imported commodities,
$c \in CMN (\subset C)$	a set of non-imported commodities.
$c \in CT (\subset C)$	a set of domestic trade inputs (distribution commodities),
$c \in CX (\subset C)$	a set of commodities with domestic output.
$f \in F$	a set of factors,
$f \in FLAB$	a set of all skill types of labour,
$f \in FLSK$	a set of higher-skilled labour,
$f \in FLUSK$	a set of lower-skilled labour,
$i \in INS$	a set of institutions (domestic and rest of the world),
$i \in INSD(\subset INS)$	a set of domestic institutions,
$i \in INSDNG(\subset INSD)$	a set of domestic nongovernment institutions,
$h \in H(\subset INSDNG)$	a set of households,

2 Parameters

$cwts_c$	weight of commodity c in the consumer price index,
$dwts_c$	weight of commodity c in the producer price index,
ica_{c_a}	quantity of c per unit of aggregate intermediate input a .
icd_{c_c}	quantity of commodity c . as trade input per unit of c produced and sold domestically,
ice_{c_c}	quantity of commodity c . as trade input per exported unit of c ,
icm_{c_c}	quantity of commodity c . as trade input per imported unit of c ,
$inta_a$	quantity of aggregate intermediate input per activity unit,
iva_a	quantity of value-added per activity unit,
pwe_c	f.o.b. export price in FCU(foreign-currency units) for ROW,

$pwec$	f.o.b. export price in FCU for ROE,
pwm_c	c.i.f. import price in FCU for ROW,
$pwme_c$	c.i.f. import price in FCU for ROE,
$qdst_c$	quantity of stock change,
$shif_{i,f}$	share of domestic institution i in income of factor f ,
$shii_{i'}$	share of net income of i' to i ($i' \in INSDNG'$; $i \in INSDNG$),
ta_a	tax rate for activity,
te_c	export tax rate,
tf_f	direct tax rate for factor f ,
tm_c	import tariff rate,
tq_c	rate of sales tax (as share of composite price inclusive of sales tax).
$trnsfr_{i,f}$	transfer from factor f to institution i ,
tva_a	rate of value-added tax for activity a ,
α_a^a	efficiency parameter in the first level nested CES activity function,
α_a^{ac}	shift parameter for domestic commodity aggregation function,
α_c^q	an Armington function shift parameter,
α_c^t	a CET function shift parameter,
α_a^{va}	efficiency parameter in the second level nested CES value-added function,
α_a^{lab}	efficiency parameter in the third level nested CES labour aggregation function,
α_a^{lsk}	efficiency parameter in the fourth level nested CES higher-skilled labour aggregation function,
α_a^{lusk}	efficiency parameter in the fourth level nested CES lower-skilled labour aggregation function,
$\beta_{c,h}^m$	marginal share of consumption spending on marketed commodity c for household h .
$\theta_{a,c}$	yield of output c per unit of activity a ,
δ_a^a	first level nested CES activity function share parameter,
$\delta_{a,c}^{ac}$	share parameter for domestic commodity aggregation function,
δ_c^q	an Armington function share parameter for ROW,
δ_c^{qe}	an Armington function share parameter for ROE,
δ_c^t	a CET function share parameter for ROW,
δ_c^{te}	a CET function share parameter for ROE,
$\delta_{f1st a}^{va}$	CES value-added function share parameter for second level nest,
$\delta_{f1l f2nd a}^{lab}$	third level nested CES function share parameter for labour aggregation,
$\delta_{f2l flsk a}^{f2l}$	fourth level nested CES function share parameter for higher-

	skilled labour aggregation,
$\delta_{f3l flusk a}^{f3l}$	fourth level nested CES function share parameter for lower-skilled labour aggregation,
ρ_a^a	first level nested CES activity function exponent,
ρ_c^q	an Armington function exponent,
ρ_c^t	a CET function exponent,
ρ_c^{ac}	domestic commodity aggregation function exponent,
ρ_a^{va}	second level nested CES value-added function exponent,
$\rho_{f1l a}^{lab}$	third level nested CES value-added function exponent,
$\rho_{f2l a}^{lsk}$	fourth level nested CES value-added function exponent for higher-skilled labour aggregation,
$\rho_{f3l a}^{lusk}$	fourth level nested CES value-added function exponent for higher-skilled labour aggregation,
$\gamma_{c h}^m$	subsistence consumption of marketed commodity c for household h ,
$\gamma_{a c h}^h$	subsistence consumption of home commodity c from activity a for household h ,

3 Exogenous Variables

\overline{CPI}	consumer price index (exogenous variable),
\overline{WFDIST}_{fa}	wage distortion factor for factor f in activity a (exogenous variable),
\overline{IADJ}	investment adjustment factor (exogenous variable),
\overline{qinv}_c	base-year quantity of fixed investment demand,
\overline{GADJ}	government consumption adjustment factor (exogenous variable),
\overline{qg}_c	base-year quantity of government demand,
\overline{QFS}_f	quantity supplied of factor (exogenous variable),
\overline{FSAV}	foreign savings (FCU) (exogenous variable),
\overline{tins}_i	exogenous direct tax rate for domestic institution i ,
$\overline{TINSADJ}$	direct tax scaling factor (= 0 for base; exogenous variable),
$\overline{tins01}_i$	0.1 parameter with 1 for institutions with potentially flexed direct tax rates,
\overline{DTINS}_i	change in domestic institution tax share (= 0 for base; exogenous variable).
\overline{mps}_i	base savings rate for domestic institution i ,

MPSADJ savings rate scaling factor (= 0 for base),

4 Endogenous variables

<i>DMPS</i>	change in domestic institution savings rates (= 0 for base; exogenous variable).
<i>DPI</i>	producer price index for domestically marketed output,
<i>EG</i>	government expenditures,
<i>EH_h</i>	household consumption expenditures,
<i>EXR</i>	exchange rate (LCU per FCU) for ROW,
<i>EXRE</i>	exchange rate (LCU per FCU) for ROE,
<i>GOVSHR</i>	government consumption share in nominal absorption,
<i>GSAV</i>	government savings,
<i>INVSHR</i>	investment share in nominal absorption,
<i>MPS_i</i>	marginal propensity to save for domestic nongovernment institution (exogenous variable),
<i>MPS01_i</i>	0-1 parameter with 1 for institutions with potentially flexed direct tax rates,
<i>PA_a</i>	activity price (gross revenue per activity unit),
<i>PDD_c</i>	demand price for commodity produced and sold domestically,
<i>PDS_c</i>	supply price for commodity produced and sold domestically,
<i>PE_c</i>	export price (LCU) for ROW,
<i>PEE_c</i>	export price (LCU) for ROE,
<i>PINTA_a</i>	aggregate intermediate input price for activity a,
<i>PM_c</i>	import price in LCU (local-currency units) including transaction costs for ROW,
<i>PME_c</i>	import price in LCU (local-currency units) including transaction costs for ROE,
<i>PVA_a</i>	price of (aggregate) value-added,
<i>PQ_c</i>	composite commodity price (including sales tax and transaction costs),
<i>PX_c</i>	aggregate producer price for commodity,
<i>PXAC_{a c}</i>	producer price of commodity c for activity a,
<i>QA_a</i>	quantity (level) of activity,
<i>QD_c</i>	quantity sold domestically of domestic output,
<i>QE_c</i>	quantity of exports to ROW,
<i>QEE_c</i>	quantity of exports to ROE,
<i>QF_{f a}</i>	quantity demanded of factor f from activity a,
<i>QG_c</i>	government consumption demand for commodity,
<i>QH_{c h}</i>	quantity of consumption of marketed commodity c for household h,
<i>QHA_{a c h}</i>	quantity of household home consumption of commodity c from activity a for household h,

$QINT_{c a}$	quantity of commodity c as intermediate input to activity a ,
$QINTA_a$	quantity of aggregate intermediate input,
$QINV_c$	quantity of fixed investment demand for commodity,
QM_c	quantity of imports of commodity from ROW,
QME_c	quantity of imports of commodity from ROE,
QQ_c	quantity of goods supplied to domestic market (composite supply),
QT_c	quantity of commodity demanded as transactions service input,
QVA_a	quantity of (aggregate) value-added,
QX_c	aggregate marketed quantity of domestic output of commodity,
$QXAC_{a c}$	marketed output quantity of commodity c from activity a ,
TABS	total nominal absorption,
$TINS_i$	direct tax rate for institution i ($i \in INSDNG$),
$TRII_{i'}$	transfers from institution i' to i (both in the set $INSDNG$),
WF_f	average price of factor, and
YF_f	income of factor f ,
YG	government revenue,
YI_i	income of institution i (in the set $INSDNG$),
$YIF_{i f}$	income to domestic institution i from factor f ,

Appendix 2: Model Files

This appendix contains the GAMS model files employed in the calibration of and the simulations carried out with the CGE-ILA model for the UK with labour immigration effects. The files are available in electronic form from the author upon request. Explanatory text is included (either by insertion of an ‘*’ at the beginning of a sentence, or using the commands \$ontext and \$offtext before and after a paragraph).

MOD.GMS

* SET DECLARATIONS

SETS

*a. model sets

AC global set for model accounts - aggregated microsam accounts

ACNT(AC) all elements in AC except TOTAL

A(AC) activities

ACES(A) activities with CES fn at top of technology nest

ALEO(A) activities with Leontief fn at top of technology nest

C(AC) commodities

CD(C) commodities with domestic sales of output

CDN(C) commodities without domestic sales of output

CE(C) exported commodities

CEN(C) non-export commodities

CM(C) imported commodities

CMN(C) non-imported commodities

CX(C) commodities with output

FT(AC) all factors

F(FT) natural factors

INS(AC) institutions

INSD(INS) domestic institutions

INSDNG(INSD) domestic non-government institutions

H(INSDNG) households

*b. calibration sets

CINV(C) fixed investment goods

CT(C) transaction service commodities

CTD(AC) domestic transactions cost account
 CTE(AC) export transactions cost account
 CTM(AC) import transactions cost account

*c. report sets

AAGR(A) agricultural activities
 ANAGR(A) non-agricultural activities
 CAGR(C) agricultural commodities
 CNAGR(C) non-agricultural commodities
 EN(INSNDNG) enterprises
 FLAB(F) labour
 FCAP(F) capital
 F1ST(FT) aggregation factor
 F1L(F1ST) aggregate labour
 F2ND(FT) second aggregation labour
 FLSK(F) aggregate higher-skilled labour
 FLUSK(F) aggregate lower-skilled labour
 F2L(F2ND) higher-skilled labour
 F3L(F2ND) lower-skilled labour

;

*ALIAS statement to create identical sets

ALIAS

(AC,ACP) , (ACNT,ACNTP), (A,AP,APP), (C,CP,CPP), (CE,CEP), (CM,CMP)
 (F,FP) , (FLAB,FLABP), (FCAP,FCAPP), (FLND,FLNDP)
 (FT,FTP), (F1ST,F1STP), (F1L,F1LP)
 (F2ND,F2NDP), (FLSK,FLSKP), (FLUSK,FLUSKP), (F2L,F2LP), (F3L,F3LP)
 (INS,INSP), (INSD,INSDP), (INSNDNG,INSNDNGP), (H,HP)

;

* EQUATION DECLARATIONS

EQUATIONS

*Price block=====

PMDEF(C) domestic import from ROW price
 PMEDEF(C) domestic import from ROE price
 PEDEF(C) domestic export to ROW price
 PEEDEF(C) domestic export to ROE price

 PDDDEF(C) demand price for commodity c produced and sold domestically
 PQDEF(C) value of sales in domestic market
 PXDEF(C) value of marketed domestic output

PADEF(A)	output price for activity a
PINTADEF(A)	price of aggregate intermediate input
PVADEF(A)	value-added price
CPIDEF	consumer price index
DPIDEF	domestic producer price index

*Production and trade block=====

CESAGGPRD(A)	First-level nested CES aggregate production function
CESAGGFOC(A)	First-level nested CES aggregate first-order condition
CESVAPRD(A)	Second-level nested CES value-added production function
CESVAFOC(F1ST,A)	Second-level nested CES value-added first-order condition
CESVAPRD2(F1L,A)	CES labour aggregation production function
CESVAFOC2(F1L,f2nd,A)	CES labour aggregation first-order condition
CESVAPRD3(F2L,A)	CES higher-skilled labour aggregation function
CESVAFOC3(F2L,flsk,A)	CES higher-skilled labour aggregation first-order condition
CESVAPRD4(F3L,A)	CES lower-skilled labour aggregation production function
CESVAFOC4(F3L,flusk,A)	CES lower-skilled labour aggregation first-order condition

INTDEM(C,A)	intermediate demand for commodity c from activity a
COMPRDFN(A,C)	production function for commodity c and activity a
OUTAGGFN(C)	output aggregation function
OUTAGGFOC(A,C)	first-order condition for output aggregation function
CET(C)	CET function
CET2(C)	domestic sales and exports for outputs without both
ESUPPLY(C)	export supply
EESUPPLY(C)	EU export supply

ARMINGTON(C)	composite commodity aggregation function
COSTMIN(C)	first-order condition for composite commodity cost min
ECOSTMIN(C)	first-order condition for composite commodity cost min from EU

ARMINGTON2(C)	composite supply for commodities without both domestic sales and imports
---------------	--

QTDEM(C)	demand for transactions (trade and transport) services
----------	--

UERATE(FLAB)	unemployment rate of labour factor
WAGERATE(F)	wage rate of factor
WAGECUR(Flab)	wage curve function

*Institution block=====

YFDEF(F)	factor incomes
----------	----------------

YIFDEF(INS,F)	factor incomes to domestic institutions
YIDDEF(INS)	total incomes of domestic non-government institutions
EHDEF(H)	household consumption expenditures
TRIIDEF(INS,INSP)	transfers to institution from other institution
HMDEM(C,H)	LES cons demand by hhd h for marketed commodity c
HADEM(A,C,H)	LES cons demand by hhd h for home commodity c from act a
INVDEM(C)	fixed investment demand
GOVDEM(C)	government consumption demand
EGDEF	total government expenditures
YGDEF	total government income

*System constraint block=====

COMEQUIL(C)	composite commodity market equilibrium
FACEQUIL(Flab)	labour market equilibrium
FACEQUI(Fcap)	capital factor equilibrium
CURACCBAL	current account balance (of ROW)
CURACCBAL1	current account balance (of ROE)
GOVBAL	government balance
TINSDEF(INS)	direct tax rate for inst ins
MPSDEF(INS)	marginal proportion to save for inst ins
SAVINVBAL	savings-investment balance
TABSEQ	total absorption
INVABEQ	investment share in absorption
GDABEQ	government consumption share in absorption
OBJEQ	Objective function

;

* EQUATION DEFINITIONS

*Price block=====

PMDEF(C)\$CM(C)..

$PM(C) = E = p_{wm}(C) * (1 + t_m(C)) * EXR + \text{SUM}(CT, PQ(CT) * icm(CT, C));$

PMEDEF(C)\$CM(C)..

$PME(C) = E = p_{wme}(C) * EXRE ;$

PEDEF(C)\$CE(C)..

$PE(C) = E = p_{we}(C) * (1 - t_e(C)) * EXR - \text{SUM}(CT, PQ(CT) * ice(CT, C));$

PEEDEF(C)\$CE(C)..

$PEE(C) = E = p_{wee}(C) * EXRE;$

PDDDEF(C)\$CD(C).. PDD(C) =E= PDS(C) + SUM(CT, PQ(CT)*icd(CT,C));

PQDEF(C)\$CD(C) OR CM(C)..

$$PQ(C)*(1 - tq(c))*QQ(C) =E= PDD(C)*QD(C) + PM(C)*QM(C) + PME(C)*QME(C);$$

PXDEF(C)\$CX(C).. PX(C)*QX(C) =E= PDS(C)*QD(C) + PE(C)*QE(C) + PEE(C)*QEE(C);

PADEF(A).. PA(A) =E= SUM(C, PXAC(A,C)*theta(A,C));

PINTADEF(A).. PINTA(A) =E= SUM(C, PQ(C)*ica(C,A)) ;

PVADEF(A).. PA(A)*(1-ta(A))*QA(A) =E= PVA(A)*QVA(A) + PINTA(A)*QINTA(A) ;

CPIDEF.. CPI =E= SUM(C, cwts(C)*PQ(C)) ;

DPIDEF.. DPI =E= SUM(CD, dwts(CD)*PDS(CD)) ;

*Production and trade block=====

CESAGGPRD(A)\$ACES(A)..

$$QA(A) =E= \alpha_{aa}(A)*(\delta_{aa}(A)*QVA(A)**(-\rho_{aa}(A)) + (1-\delta_{aa}(A))*QINTA(A)**(-\rho_{aa}(A)))**(-1/\rho_{aa}(A)) ;$$

CESAGGFOC(A)\$ACES(A)..

$$QVA(A) =E= QINTA(A)*((PINTA(A)/PVA(A))*(\delta_{aa}(A)/(1 - \delta_{aa}(A))))**1/(1+\rho_{aa}(A)) ;$$

CESVAPRD(A)..

$$QVA(A) =E= \alpha_{ava}(A)*(SUM(F1ST, \delta_{ava}(F1ST,A)*QF(F1ST,A)**(-\rho_{ava}(A)))**(-1/\rho_{ava}(A)) ;$$

CESVAFOC(F1ST,A)\$delta(F1ST,A)..

$$WF(F1ST)*wfdist(F1ST,A) =E= PVA(A)*(1-tva(A)) * QVA(A) * SUM(F1STP, \delta_{ava}(F1STP,A)*QF(F1STP,A)**(-\rho_{ava}(A)))**(-1) * \delta_{ava}(F1ST,A)*QF(F1ST,A)**(-\rho_{ava}(A)-1);$$

CESVAPRD2(F1L,A)..

$$QF(F1L,a) =E= \alpha_{fab}(f1l,A)*(SUM(F2nd, \delta_{fab}(f1l,f2nd,a),$$

$$\text{deltalab}(f11, F2nd, A) * QF(F2nd, A) ** (-\text{rholab}(f11, A)) ** (-1/\text{rholab}(f11, A)) ;$$

CESVAFOC2(F1L, f2nd, A)\$deltalab(F1L, f2nd, A)..

$$\begin{aligned} WF(F2nd) * \text{wfdist}(F2nd, A) = E = \\ \text{wf}(F1L) * \text{wfdist}(F1L, a) * QF(F1L, A) \\ * \text{SUM}(F2ndp \$ \text{deltalab}(f11, f2ndp, a), \text{deltalab}(f11, F2ndp, A) \\ * QF(F2ndp, A) ** (-\text{rholab}(f11, A)) ** (-1) \\ * \text{deltalab}(f11, F2nd, A) * QF(F2nd, A) ** (-\text{rholab}(f11, A) - 1); \end{aligned}$$

CESVAPRD3(F2L, A)..

$$\begin{aligned} QF(F2L, a) = E = \text{alphask}(f21, A) * (\text{SUM}(\text{Flsk} \$ \text{deltask}(f21, \text{flsk}, a), \\ \text{deltask}(f21, \text{Flsk}, A) * QF(\text{Flsk}, A) ** (-\text{rholsk}(f21, A)) ** (-1/\text{rholsk}(f21, A)) ; \end{aligned}$$

CESVAFOC3(F2L, flsk, A)\$deltask(F2L, flsk, A)..

$$\begin{aligned} WF(\text{Flsk}) * \text{wfdist}(\text{Flsk}, A) = E = \\ \text{wf}(F2L) * \text{wfdist}(F2L, a) * QF(F2L, A) \\ * \text{SUM}(\text{Flskp} \$ \text{deltask}(f21, \text{flskp}, a), \text{deltask}(f21, \text{Flskp}, A) \\ * QF(\text{Flskp}, A) ** (-\text{rholsk}(f21, A)) ** (-1) \\ * \text{deltask}(f21, \text{Flsk}, A) * QF(\text{Flsk}, A) ** (-\text{rholsk}(f21, A) - 1); \end{aligned}$$

CESVAPRD4(F3L, A)..

$$\begin{aligned} QF(F3L, a) = E = \text{alphalusk}(f31, A) * (\text{SUM}(\text{Flusk} \$ \text{deltalusk}(f31, \text{flusk}, a), \\ \text{deltalusk}(f31, \text{Flusk}, A) * QF(\text{Flusk}, A) ** (-\text{rholusk}(f31, A)) ** (-1/\text{rholusk}(f31, A)) ; \end{aligned}$$

CESVAFOC4(F3L, flusk, A)\$deltalusk(F3L, flusk, A)..

$$\begin{aligned} WF(\text{Flusk}) * \text{wfdist}(\text{Flusk}, A) = E = \\ \text{wf}(F3L) * \text{wfdist}(F3L, a) * QF(F3L, A) \\ * \text{SUM}(\text{Fluskp} \$ \text{deltalusk}(f31, \text{fluskp}, a), \text{deltalusk}(f31, \text{Fluskp}, A) \\ * QF(\text{Fluskp}, A) ** (-\text{rholusk}(f31, A)) ** (-1) \\ * \text{deltalusk}(f31, \text{Flusk}, A) * QF(\text{Flusk}, A) ** (-\text{rholusk}(f31, A) - 1); \end{aligned}$$

INTDEM(C, A)\$ica(C, A).. QINT(C, A) =E= ica(C, A)*QINTA(A);

COMPRDFN(A, C)\$theta(A, C)..

$$QXAC(A, C) + \text{SUM}(H, QHA(A, C, H)) = E = \text{theta}(A, C) * QA(A) ;$$

OUTAGGFN(C)\$CX(C)..

$$\begin{aligned} QX(C) = E = \\ \text{alphaac}(C) * \text{SUM}(A, \text{deltaac}(A, C) * QXAC(A, C) ** (-\text{rhoac}(C)) ** (-1/\text{rhoac}(C))); \end{aligned}$$

OUTAGGFOC(A, C)\$deltaac(A, C)..

$$PXAC(A, C) = E =$$

$$\text{PX}(C) * \text{QX}(C) * \text{SUM}(\text{AP}, \text{deltaac}(\text{AP}, C) * \text{QXAC}(\text{AP}, C) ** (-\text{rhoac}(C))) ** (-1) \\ * \text{deltaac}(A, C) * \text{QXAC}(A, C) ** (-\text{rhoac}(C) - 1);$$

CET(C)\$ (CE(C) AND CD(C))..

$$\text{QX}(C) = \text{E} = \text{alphat}(C) * (\text{deltat}(C) * \text{QE}(C) ** \text{rhot}(C) + \text{deltate}(C) * \text{QEE}(C) ** \text{rhot}(C) + \\ (1 - \text{deltat}(C) - \text{deltate}(C)) * \text{QD}(C) ** \text{rhot}(C)) ** (1 / \text{rhot}(C));$$

ESUPPLY(C)\$ (CE(C) AND CD(C))..

$$\text{QE}(C) = \text{E} = \text{QD}(C) * ((\text{PE}(C) / \text{PDS}(C)) * \\ ((1 - \text{deltat}(C) - \text{deltate}(C)) / \text{deltat}(C))) ** (1 / (\text{rhot}(C) - 1));$$

EESUPPLY(C)\$ (CE(C) AND CD(C))..

$$\text{QEE}(C) = \text{E} = \text{QD}(C) * ((\text{PEE}(C) / \text{PDS}(C)) * \\ ((1 - \text{deltat}(C) - \text{deltate}(C)) / \text{deltate}(C))) ** (1 / (\text{rhot}(C) - 1));$$

CET2(C)\$ ((CD(C) AND CEN(C)) OR (CE(C) AND CDN(C)))..

$$\text{QX}(C) = \text{E} = \text{QD}(C) + \text{QE}(C) + \text{QEE}(C);$$

ARMINGTON(C)\$ (CM(C) AND CD(C))..

$$\text{QQ}(C) = \text{E} = \text{alphaq}(C) * (\text{deltaq}(C) * \text{QM}(C) ** (-\text{rhoq}(C)) + \text{deltaqe}(C) * \text{QME}(C) ** (- \\ \text{rhoq}(C)) + (1 - \text{deltaq}(C) - \text{deltaqe}(C)) * \text{QD}(C) ** (-\text{rhoq}(C))) ** (-1 / \text{rhoq}(C));$$

COSTMIN(C)\$ (CM(C) AND CD(C))..

$$\text{QM}(C) = \text{E} = \text{QD}(C) * ((\text{PDD}(C) / \text{PM}(C)) * (\text{deltaq}(C) / (1 - \text{deltaq}(C) - \text{deltaqe}(C)))) \\ ** (1 / (1 + \text{rhoq}(C)));$$

ECOSTMIN(C)\$ (CM(C) AND CD(C))..

$$\text{QME}(C) = \text{E} = \text{QD}(C) * ((\text{PDD}(C) / \text{PME}(C)) * (\text{deltaqe}(C) / (1 - \text{deltaqe}(C) - \text{deltaq}(C)))) \\ ** (1 / (1 + \text{rhoq}(C)));$$

ARMINGTON2(C)\$ ((CD(C) AND CMN(C)) OR (CM(C) AND CDN(C)))..

$$\text{QQ}(C) = \text{E} = \text{QD}(C) + \text{QM}(C) + \text{QME}(C);$$

QTDEM(C)\$CT(C)..

$$\text{QT}(C) = \text{E} = \text{SUM}(\text{CP}, \text{icm}(C, \text{CP}) * \text{QM}(\text{CP}) + \text{ice}(C, \text{CP}) * \text{QE}(\text{CP}) + \\ \text{icd}(C, \text{CP}) * \text{QD}(\text{CP}));$$

UERATE(flav).. UER(FLAB) =E= (QFS(flav) - SUM(A, QF(FLAB, A))) / QFS(FLAB);

WAGERATE(F).. WR(F) =e= WF(F) / CPI;

*Institution block =====

YFDEF(F).. YF(F) =E= SUM(A, WF(F) * wfdist(F, A) * QF(F, A));

YIFDEF(INSDF,F)\$shif(INSDF,F)..

$$YIF(INSDF,F) = E = shif(INSDF,F) * ((1 - tf(f)) * YF(F) - trnsfr('ROW',F) * EXR - trnsfr('ROE',F) * EXRE);$$

YIDEF(INSDNG)..

$$YI(INSDNG) = E = SUM(F, YIF(INSDNG,F)) + SUM(INSDNGP, TRII(INSDNG,INSDNGP)) + trnsfr(INSDNG,'GOV') * CPI + trnsfr(INSDNG,'ROW') * EXR + trnsfr(INSDNG,'ROE') * EXRE;$$

TRIIDEF(INSDNG,INSDNGP)\$(shii(INSDNG,INSDNGP))..

$$TRII(INSDNG,INSDNGP) = E = shii(INSDNG,INSDNGP) * (1 - MPS(INSDNGP)) * (1 - TINS(INSDNGP)) * YI(INSDNGP);$$

EHDEF(H)..

$$EH(H) = E = (1 - SUM(INSDNG, shii(INSDNG,H))) * (1 - MPS(H)) * (1 - TINS(H)) * YI(H);$$

HMDDEM(C,H)\$betam(C,H)..

$$PQ(C) * QH(C,H) = E = PQ(C) * gammam(C,H) + betam(C,H) * (EH(H) - SUM(CP, PQ(CP) * gammam(CP,H)) - SUM((A,CP), PXAC(A,CP) * gammah(A,CP,H)));$$

HADEM(A,C,H)\$betah(A,C,H)..

$$PXAC(A,C) * QHA(A,C,H) = E = PXAC(A,C) * gammah(A,C,H) + betah(A,C,H) * (EH(H) - SUM(CP, PQ(CP) * gammam(CP,H)) - SUM((AP,CP), PXAC(AP,CP) * gammah(AP,CP,H)));$$

INVDEM(C)\$CINV(C).. QINV(C) = E = IADJ * qbarinv(C);

GOVDEM(C).. QG(C) = E = GADJ * qbarg(C);

YGDEF..

$$YG = E = SUM(INSDNG, TINS(INSDNG) * YI(INSDNG)) + SUM(f, tf(F) * YF(F)) + SUM(A, tva(A) * PVA(A) * QVA(A)) + SUM(A, ta(A) * PA(A) * QA(A)) + SUM(C, tm(C) * pwm(C) * QM(C)) * EXR + SUM(C, te(C) * pwe(C) * QE(C)) * EXR + SUM(C, tq(C) * PQ(C) * QQ(C))$$

$$+ \text{SUM}(F, \text{YIF}('GOV',F)) \\ + \text{trnsfr}('GOV', 'ROW') * \text{EXR} + \text{trnsfr}('GOV', 'ROE') * \text{EXRE};$$

EGDEF..

$$\text{EG} = \text{E} = \text{SUM}(C, \text{PQ}(C) * \text{QG}(C)) + \text{SUM}(\text{INSDNG}, \text{trnsfr}(\text{INSDNG}, 'GOV')) * \text{CPI};$$

*System constraint block=====

$$\text{FACEQUIL}(\text{Flab}).. \text{SUM}(A, \text{QF}(\text{Flab}, A)) = \text{E} = \text{QFS}(\text{Flab}) * (1 - \text{UER}(\text{Flab}));$$

$$\text{FACEQUI}(\text{Fcap}).. \text{SUM}(A, \text{QF}(\text{Fcap}, A)) = \text{E} = \text{QFS}(\text{Fcap});$$

COMEQUIL(C)..

$$\text{QQ}(C) = \text{E} = \text{SUM}(A, \text{QINT}(C, A)) + \text{SUM}(H, \text{QH}(C, H)) + \text{QG}(C) \\ + \text{QINV}(C) + \text{qdst}(C) + \text{QT}(C);$$

CURACCBAL..

$$\text{SUM}(C, \text{pwm}(C) * \text{QM}(C)) + \text{SUM}(F, \text{trnsfr}('ROW', F)) = \text{E} = \\ \text{SUM}(C, \text{pwe}(C) * \text{QE}(C)) + \text{SUM}(\text{INSD}, \text{trnsfr}(\text{INSD}, 'ROW')) + \text{FSAV};$$

CURACCBAL1..

$$\text{SUM}(C, \text{pwme}(C) * \text{QME}(C)) + \text{SUM}(F, \text{trnsfr}('ROE', F)) = \text{E} = \\ \text{SUM}(C, \text{PWEE}(C) * \text{QEE}(C)) + \text{SUM}(\text{INSD}, \text{trnsfr}(\text{INSD}, 'ROE')) + \text{FSAVE};$$

$$\text{GOVBAL}.. \text{YG} = \text{E} = \text{EG} + \text{GSAV};$$

TINSDEF(INSDNG)..

$$\text{TINS}(\text{INSDNG}) = \text{E} = \text{tinsbar}(\text{INSDNG}) * (1 + \text{TINSADJ} * \text{tins01}(\text{INSDNG})) \\ + \text{DTINS} * \text{tins01}(\text{INSDNG});$$

MPSDEF(INSDNG)..

$$\text{MPS}(\text{INSDNG}) = \text{E} = \text{mpsbar}(\text{INSDNG}) * (1 + \text{MPSADJ} * \text{mps01}(\text{INSDNG})) \\ + \text{DMPS} * \text{mps01}(\text{INSDNG});$$

SAVINVBAL..

$$\text{SUM}(\text{INSDNG}, \text{MPS}(\text{INSDNG}) * (1 - \text{TINS}(\text{INSDNG})) * \text{YI}(\text{INSDNG})) \\ + \text{GSAV} + \text{FSAV} * \text{EXR} + \text{FSAVE} * \text{EXRE} = \text{E} = \\ \text{SUM}(C, \text{PQ}(C) * \text{QINV}(C)) + \text{SUM}(C, \text{PQ}(C) * \text{qdst}(C)) + \text{WALRAS};$$

TABSEQ..

$$\text{TABS} = \text{E} = \\ \text{SUM}((C, H), \text{PQ}(C) * \text{QH}(C, H)) + \text{SUM}((A, C, H), \text{PXAC}(A, C) * \text{QHA}(A, C, H)) \\ + \text{SUM}(C, \text{PQ}(C) * \text{QG}(C)) + \text{SUM}(C, \text{PQ}(C) * \text{QINV}(C)) + \text{SUM}(C, \text{PQ}(C) * \text{qdst}(C));$$

INVABEQ.. INVSHR*TABS =E= SUM(C, PQ(C)*QINV(C)) + SUM(C, PQ(C)*qdst(C));

GDABEQ.. GOVSHR*TABS =E= SUM(C, PQ(C)*QG(C));

OBJEQ.. WALRASSQR =E= WALRAS*WALRAS ;

UK-DATA.DAT

SETS

AC global set for model accounts - aggregated microsam accounts

/

*activities

- A1 agriculture
- A2 energy and water supply
- A3 manufacturing
- A4 construction
- A5 distribution and hotel
- A6 transport and communication
- A7 finance and business services
- A8 public administration and education
- A9 other services

*commodities

- C1 agriculture
- C2 energy and water supply
- C3 manufacturing
- C4 construction
- C5 distribution and hotel
- C6 transport and communication
- C7 finance and business services
- C8 public administration and education
- C9 other services

*factors

- L1 senior officials, managers and professions
- L2 technicians, associate professionals and clerks
- L3 service workers, skilled agricultural and elementary occupations
- L4 trade workers, machine operators and assemblers
- CAP capital
- lab labour aggregate
- lsk higher-skilled labour
- lusk lower-skilled labour

*households

HH1 The first quintile households
 HH2 The second quintile households
 HH3 The third quintile households
 HH4 The fourth quintile households
 HH5 The fifth quintile households

*enterprises

ENTR enterprises

*taxes

YTAX direct income tax collection
 ATAX indirect activity tax collection
 STAX domestic sale tax

*Required accounts

GOV government
 S-I savings-investment
 DSTK stock changes
 ROE EU countries in rest of world
 ROW non-EU countries in rest of world

TRNCSTDOM domestic transactions cost account

TRNCSTEXP export transactions cost account

TRNCSTIMP import transactions cost account

INSTAX direct taxes on domestic institutions

FACTAX direct factor taxes

IMPTAX import taxes

EXPTAX export taxes

VATAX value-added taxes

ACTAX indirect taxes on activity revenue

COMTAX indirect taxes on commodity sales in domestic market

DUM dummy

TOTAL total

/

A(AC) activities

/

A1

A2

A3

A4

A5

A6

A7

A8

A9

/

AAGR(A) agricultural activities

/

A1

/

;

ACES(A) = NO;

ALEO(A)\$(NOT ACES(A)) = YES;

ANAGR(A) = NOT AAGR(A);

SET

C(AC) commodities

/

C1

C2

C3

C4

C5

C6

C7

C8

C9

/

CAGR(C) agricultural commodities

/

C1

/

;

CNAGR(C) = NOT CAGR(C);

SETS

CTD(AC) domestic transactions cost account //

CTE(AC) export transactions cost account //

CTM(AC) import transactions cost account //

FT(AC) all factora

/

L1

L2

L3

L4

CAP

lab

lsk

lusk

/

F(FT) natural factors

/

L1

L2

L3

L4

CAP

/

FLAB(F) labour

/

L1

L2

L3

L4

/

FCAP(F) capital

/

CAP

/

F1st(ft) first aggregate

/

lab

cap

/

F1L(F1ST) aggregate labour

/

lab

/

F2ND(ft) second aggregate labour

/

lsk

lusk

/

F2L(F2ND)

/

lsk

/

F3L(F2ND)

/

lusk

/

flsk(f) aggregate higher-skilled labour

/

L1

L2

/

flusk(f) aggregate lower-skilled labour

/

L3

L4

/

INS(AC) institutions

/

HH1

HH2

HH3

HH4

HH5

ENTR

GOV

ROE

ROW

/

INSD(INS) domestic institutions

/

HH1

HH2

HH3

HH4

HH5

ENTR

GOV

/

INSDNG(INS) domestic non-government institutions

/

HH1

HH2

HH3

HH4

HH5

ENTR

/

EN(INSDNG) enterprises

/

ENTR

/

H(INSDNG) households

/

HH1

HH2

HH3

HH4

HH5

/

;

ACNT(AC) = YES; ACNT('TOTAL') = NO;

DISPLAY

ACES, ALEO, AAGR, ANAGR, CAGR, CNAGR

;

*2. SOCIAL ACCOUNTING MATRIX

TABLE UKSAM(AC,ACP) 9-SECTOR MICROSAM FOR UK (million pounds 2004)

\$CALL GDXXRW.EXE c:\model\UK-SAM.xls par=Level rng=A1:AO41

*=== Now import data from GDX

Parameter Level(ac,acp);

\$GDXIN UK-SAM.gdx

\$LOAD Level

\$GDXIN

*=== Fix variables to values from Excel file

uksam(ac,acp) = Level(ac,acp);

display Level;

SAM(AC,ACP) = UKSAM(AC,ACP)/1000;

SAM('TOTAL',AC) = 0;

SAM(AC,'TOTAL') = 0;

SAM('TOTAL',AC) = SUM(ACNT, SAM(ACNT,AC));

SAM(AC,'TOTAL') = SUM(ACNT, SAM(AC,ACNT));

SAMBALCHK(AC) = SAM('TOTAL',AC) - SAM(AC,'TOTAL');

DISPLAY "Read in SAM", SAMBALCHK;

DISPLAY "Read in SAM", SAM;

\$INCLUDE c:\model\SAMBAL.INC

\$STITLE Input file: uk-sam0419.DAT. Standard CGE modeling system, Version 1.01

CINV(C)\$SAM(C,'S-I') = YES;

DISPLAY CINV

*3 ELASTICITIES

*Trade elasticities

SET

TRDELAS trade elasticity

/
 SIGMAQ Armington elasticity
 SIGMAT CET elasticity
 /

TABLE TRADELAS(AC,TRDELAS) Armington and CET elasticities by commodity

	SIGMAQ	SIGMAT
C1	1.4	2
C2	2	2
C3	1.3	2
C4	2	2
C5	2	2
C6	2	2
C7	2	2
C8	2	2
C9	2	2

*Production elasticities

PARAMETER

PRODELAS1(A) Elas of substit bt. lab and cap - level 2 of technology nest

/
 A1 0.5
 A2 1.2
 A3 0.4
 A4 0.7
 A5 0.6
 A6 0.3
 A7 0.6
 A8 0.8
 A9 0.8

/

PRODELAS3(A) Elas of substit bt. aggregate labours - level3 technology nest

/
 A1 1.3
 A2 0.6
 A3 1.1
 A4 1.1
 A5 1.1
 A6 1.1
 A7 0.7

A8 0.9

A9 0.9

/

PRODELAS4(A) Elas of substit bt. 11 and 12 - level 4 of technology nest

/

A1 1.2

A2 1.3

A3 1.3

A4 1.2

A5 1.1

A6 1.5

A7 1.5

A8 1.6

A9 1.7

/

PRODELAS5(A) Elas of substit bt. 13 and 14 - level 4 of technology nest

/

A1 1.7

A2 1.7

A3 1.9

A4 1.9

A5 0.7

A6 1.5

A7 0.6

A8 0.9

A9 0.9

/

PRODELAS2(A) Elas of substit bt. agg fac & intermed - top of tech nest

ELASAC(C) output aggregation elasticity for commodity C;

;

PRODELAS2(A) = 0.3;

ELASAC(C) = 6;

*Household population data=====

PARAMETER

POP(H) Base-year population for household h (units)

/

/

*Household consumption elasticities=====

*Note: The Frisch parameter is included in this section.

TABLE LESELAS1(C,H) Exp'e elasticity of market dem for com c by hhd h

	HH1	HH2	HH3	HH4	HH5
C1	0.4	0.4	0.4	0.4	0.4
C2	1.1	1.1	1.1	1.1	1.1
C3	1.2	1.2	1.2	1.2	1.2
C4	1.2	1.2	1.2	1.2	1.2
C5	1.3	1.3	1.3	1.3	1.3
C6	1.2	1.2	1.2	1.2	1.2
C7	1.2	1.2	1.2	1.2	1.2
C8	1.2	1.2	1.2	1.2	1.2
C9	1.3	1.3	1.3	1.3	1.3

;

PARAMETERS

FRISCH(H) Frisch parameter for household LES demand

LESELAS2(A,C,H) Exp'e elasticity of home dem by com - act - hhd

;

FRISCH(H) = -1;

LESELAS2(A,C,H) = 0;

*4. PHYSICAL FACTOR QUANTITIES

PARAMETER

QFSBASE(F) base-year qnty of supply for factor f

/

/

TABLE QFBASE(F,A) qnty of factor f employed by activity a

*Units: for labour factors -- hundred thousand workers

	A1	A2	A3	A4	A5	A6	A7	A8	A9
L1	0.378	0.8798	9.4758	3.8974	12.3600	3.3260	17.4885	24.3146	3.4022
L2	0.2373	0.6893	7.3691	2.9072	6.9133	3.3755	17.6434	28.5540	5.3382
L3	0.9631	0.3886	4.2185	2.3988	28.4521	5.6976	6.6726	21.8450	6.7218

L4 1.9833 0.6979 16.667 13.664 7.9687 6.6188 1.571 1.9825 1.5131
;

*5. COMMODITY VALUE SHARES FOR HOME CONSUMPTION

PARAMETER

shrhome(A,C,H) value share for comm'y c in home cons of hhd h from act a
;

*!: If needed, manually define shrhome.

shrhome(A,C,H) = 0;

*6. INITIALIZATION OF TAX DATA

SET

TX taxes in the model

/

INSTAX direct taxes on domestic institutions

FACTAX direct factor taxes

IMPTAX import taxes

EXPTAX export taxes

VATAX value-added taxes

ACTTAX taxes on activity revenue

COMTAX taxes on commodity sales in domestic market

/

;

PARAMETER

TAXPAR(TX,AC) payment by account ac to tax account tx

;

ALIAS(TX,TXP);

*direct taxes on domestic institutions

TAXPAR('INSTAX',INSD) = SAM('YTAX',INSD);

*direct factor taxes

TAXPAR('FACTAX',F) = SAM('YTAX',F);

*import taxes

TAXPAR('IMPTAX',C) = SAM('IMPTAX',C);

*export taxes

TAXPAR('EXPTAX',C) = 0;

*value-added taxes

TAXPAR('VATAX',A) = 0;

*taxes on activity revenue

TAXPAR('ACTTAX',A) = SAM('ATAX',A);

*taxes on commodity sales in domestic market

TAXPAR('COMTAX',C) = SAM('STAX',C);

THE END OF UK-DATA.DAT

Appendix 3: The Micro SAM for UK 2004

	A1	A2	A3	A4	A5	A6	A7	A8	A9	C1	C2	C3	C4	C5	C6	C7	C8
A1										21096	1	139	112	602	4	439	
A2											79384	216	607	760	762	1371	
A3											180	380352	200	17711	1322	13039	
A4													168132	758	35	1333	9
A5													212	304696	6	5573	4
A6													1495	1931	162410	3045	1
A7													1416	2652	454	540838	921
A8													213	330		1165	335022
A9												21	219	2016		6643	19
C1	2456	5	10172	227	1904	55	14	233	44								
C2	411	29385	24337	2727	2396	1050	1678	2799	577								
C3	5939	5659	177807	28013	48132	20025	14106	49650	7279								
C4	278	1854	1482	51162	1751	1926	12212	5291	602								
C5	708	284	1370	1240	6436	2817	5681	3637	721								
C6	467	1631	14017	1199	31238	34545	25342	9392	2731								
C7	1886	4902	31736	20390	55203	25538	179929	34070	16549								
C8	186	195	1622	398	1169	1935	9177	32621	1017								
C9	234	206	2793	164	1934	1726	3890	6156	14946								
L1	612	3762	41965	8639	38378	16168	92700	83152	12713								
L2	271	1856	22185	4668	14134	11267	38563	54301	11667								
L3	1012	853	10445	3674	40769	14475	10235	27285	8531								
L4	1543	1299	30022	14326	9064	12264	2205	2180	1534								
CAP	7289	29890	40343	32809	50228	23889	148187	25802	20157								
HH1																	
HH2																	
HH3																	
HH4																	
HH5																	
ENTR																	
YTAX																	
ATAX	-404	1319	2508	631	8020	1217	2459	163	941								
STAX										-1672	2418	77147	13607	13004	2259	14962	2017
IMPTAX										-37	80	1909	2	44	17	79	1
Gov																	
S-I																	
DSTK																	
ROE										3643	1179	142768	71	8221	12528	12305	1309
ROW										2898	14349	100238	133	5416	6104	14545	945
DTM										3847	1964	217991					
TOTAL	22888	83100	412804	170267	310757	168896	546378	336732	100009	29775	99555	920781	186419	358141	185901	615337	340248

The Micro SAM for UK 2004 (Cont.)

	C9	L1	L2	L3	L4	CAP	HH1	HH2	HH3	HH4	HH5	ENTR	YTAX	ATAX	STAX	IMPTAX	Gov
A1	495																
A2																	
A3																	
A4																	
A5	266																
A6	14																
A7	97																
A8	2																
A9	91091																
C1							2234	2580	2661	2653	2296						
C2							3643	3800	3719	3745	3845						
C3							28436	51115	62996	80640	101858						
C4							486	907	1280	1636	1804						
C5							14568	17012	24449	26848	19789						
C6							2857	5729	8581	11882	16332						
C7							8167	18914	30309	39016	52969						
C8							2198	5478	7978	10452	22778						238897
C9							3947	7658	10443	13282	17515						11811
L1																	
L2																	
L3																	
L4																	
cap																	
HH1		1215	669	3714	4356	0							11316				46475
HH2		11547	8260	16319	16552	6869							23142				39537
HH3		36950	30498	30874	20691	12288							22191				29642
HH4		87295	48576	35600	21287	16284							13716				16541
HH5		161049	70894	30758	11543	31232							7015				7050
ENTR						261444											
YTAX						50477	1352	9799	25775	41940	67663	34301					
ATAX																	
STAX	6475																
IMPTAX	51																
Gov													231307	16854	130218	2145	
S-I									6668	10001	16669	149763					-9287
DSTK																	
ROE	3335	305	158	124	80												
ROW	3682	230	119	94	61												
DTM																	
TOTAL	105508	298592	159173	117483	74570	378594	67890	122990	184858	242095	323518	261444	231307	16854	132363	2145	380666

The Micro SAM for UK 2004 (Cont.)

	S-I	DSTK	ROE	ROW	DTM	TOTAL
A1						22888
A2						83100
A3						412804
A4						170267
A5						310757
A6						168896
A7						546378
A8						336732
A9						100009
C1	775	-224	1224	467		29775
C2	387	-1	9472	5584		99555
C3	60976	1707	101678	74766		920781
C4	100511	2899	95	244		186419
C5	376		3386	5017	223802	358141
C6	993		8354	10611		185901
C7	26907	395	27556	40900		615337
C8	1181	23	1180	1762		340248
C9	2348	56	1937	4463		105508
L1			279	224		298592
L2			144	116		159173
L3			114	91		117482
L4			73	59		74569
cap						378594
HH1			126	19		67890
HH2			666	98		122990
HH3			1503	222		184858
HH4			2436	360		242095
HH5			3465	512		323518
ENTR						261444
YTAX						231307
ATAX						16854
STAX						130218
IMPTAX						2145
Gov			124	18		380666
S-I			22213	3282		199309
DSTK	4855					4855
ROE						186026
ROW						148814
DTM						223802
TOTAL	199309	4855	186026	148814	223802	

Source: Author calculation from UK Input-Output Supply and Use Table 2006,

Note: All values are in millions of British pound;

A1 to A9 are activity account of 9 sectors, C1 to C9 are commodity account of 9 sectors, L1 to L4 are labour account of value-added, CAP is capital account of value-added, HH1 to HH5 are household account, ENTR is enterprise account, YTAX is direct income tax, ATAX is indirect activity tax, STAX is domestic sale tax, IMPTAX is import tax, GOV is government account, S-I is savings-investment account, DSTK is stock changes account, ROE is rest of EU account, ROW is rest of world account, DTM is distributors' trading margin account, TOTAL is total account.

Appendix 4: The Rest Results of Scenarios

Table 7.4C Impacts on absorption, private consumption, fixed investment and tax revenue (-1%)

	Baseline value	Scenarios' results: Percentage deviations ($\Delta\%$)				
		B1	B2	B3	B4	B5
Real Absorption (Billion £)	1229.82	-0.276	-0.144	-0.075	-0.043	-0.538
Private consumption (Billion £)	781.92	-0.149	-0.073	-0.043	-0.028	-0.292
Fixed investment (Billion £)	190.59	-1.167	-0.631	-0.306	-0.164	-2.274
Indirect Tax Revenue (Billion £)	156.49	-0.327	-0.170	-0.085	-0.066	-0.649

Table 7.5B Impacts on international trade under Group B scenarios (+10%)

	Baseline value	Scenarios' results: Percentage deviations ($\Delta\%$)				
		B1	B2	B3	B4	B5
Exports to ROW (Billion £)	150.19	2.526	1.228	0.489	0.647	4.904
Exports to ROE (Billion £)	158.02	2.361	1.162	0.452	0.834	4.827
Imports from ROW (Billion £)	-155.86	2.470	1.292	0.592	0.490	4.803
Imports from ROE (Billion £)	-192.69	2.436	1.267	0.566	0.439	4.663

Table 7.5C Impacts on international trade under Group C scenarios (-1%)

	Baseline value	Scenarios' results: Percentage deviations ($\Delta\%$)				
		C1	C2	C3	C4	C5
Exports to ROW (Billion £)	150.19	-0.276	-0.134	-0.057	-0.074	-0.540
Exports to ROE (Billion £)	158.02	-0.258	-0.127	-0.052	-0.095	-0.533
Imports from ROW (Billion £)	-155.86	-0.274	-0.142	-0.070	-0.056	-0.543
Imports from ROE (Billion £)	-192.69	-0.270	-0.140	-0.067	-0.050	-0.527

Table 7.7C Impacts on unemployment rate under Group C scenarios (-1%)

	Baseline value	Percentage deviations from baseline ($\Delta\%$)				
		Scenario C1	Scenario C2	Scenario C3	Scenario C4	Scenario C5
Highly-skilled labour	0.018	-5.556	-0.486	0.152	0.112	-5.769
Skilled labour	0.024	-1.056	-5.169	0.133	0.115	-5.944
Semi-skilled labour	0.091	0.279	0.117	-4.261	-0.068	-3.938
Unskilled labour	0.073	2.023	1.061	0.184	-4.291	-1.083
Total	0.051	0.240	-0.167	-2.318	-1.264	-3.560

Table 7.9B Impacts on employment under Group B scenarios (+10%)

	Baseline value (,000)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario B1	Scenario B2	Scenario B3	Scenario B4	Scenario B5
Highly-skilled labour	7,552	8.611	-0.083	0.023	0.017	8.542
Skilled labour	7,303	-0.249	8.317	0.028	0.024	8.002
Semi-skilled labour	7,736	0.257	0.108	5.062	-0.059	5.437
Unskilled labour	5,267	1.341	0.732	0.115	5.972	8.810
Total	27,857	2.594	2.326	1.441	1.124	7.589

Table 7.9C Impacts on Employment under Group C scenarios (-1%)

	Baseline value (,000)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario C1	Scenario C2	Scenario C3	Scenario C4	Scenario C5
Highly-skilled labour	7,552	-0.899	0.009	-0.003	-0.002	-0.895
Skilled labour	7,303	0.026	-0.874	-0.003	-0.003	-0.855
Semi-skilled labour	7,736	-0.028	-0.012	-0.578	0.007	-0.610
Unskilled labour	5,267	-0.159	-0.084	-0.014	-0.665	-0.916
Total	27,857	-0.275	-0.246	-0.165	-0.125	-0.809

Table 7.10B Impacts on factor incomes under Group B scenarios (+10%)

	Baseline value (£ Bil.)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario B1	Scenario B2	Scenario B3	Scenario B4	Scenario B5
Highly-skilled labour	300.28	1.034	-0.894	0.081	0.139	0.343
Skilled labour	161.42	-1.694	1.616	0.040	0.112	0.019
Semi-skilled labour	115.03	0.613	0.261	0.325	-0.450	0.657
Unskilled labour	77.46	2.612	1.372	-0.206	1.011	4.784
Total	654.19	0.474	0.196	0.080	0.132	0.844
Capital	378.79	5.139	2.622	1.180	0.869	10.033

Table 7.10C Impacts on factor incomes under Group C scenarios (-1%)

	Baseline value (£ Bil.)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario C1	Scenario C2	Scenario C3	Scenario C4	Scenario C5
Highly-skilled labour	300.28	-0.116	0.098	-0.010	-0.016	-0.044
Skilled labour	161.42	0.185	-0.178	-0.005	-0.013	-0.011
Semi-skilled labour	115.03	-0.067	-0.028	-0.037	0.052	-0.081
Unskilled labour	77.46	-0.289	-0.151	0.022	-0.117	-0.535
Total	654.19	-0.054	-0.022	-0.009	-0.015	-0.101
Capital	378.79	-0.550	-0.283	-0.138	-0.099	-1.068

Table 7.12B Impacts on domestic institutions' income under Group B Scenarios

	Baseline value (Billion £)	Percentage deviations from baseline ($\Delta\%$)				
		Scenario B1	Scenario B2	Scenario B3	Scenario B4	Scenario B5
HH1	72.52	0.88	0.45	0.11	0.17	1.64
HH2	126.72	1.59	0.85	0.27	0.31	3.04
HH3	190.52	1.24	0.76	0.25	0.25	2.52
HH4	247.08	0.98	0.48	0.20	0.21	1.86
HH5	323.52	0.90	0.29	0.21	0.19	1.59
Enterprise	260.42	5.14	2.62	1.18	0.87	10.03
Govt.	388.64	2.88	1.47	0.66	0.47	5.53