Foreign Direct Investment and Population Health in Low and Middle Income Countries

An Econometric Investigation

A thesis submitted in partial fulfilment for the degree of Doctor of Philosophy

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1^{st} October 2013 to the 10^{th} April 2018

Dedication

I dedicate this to Teresa Martin. Without her support and encouragement, I would have stood little chance of keeping it together, never mind completing a thesis.

Abstract

Opinions are divided on the health impacts of multi-national corporations (MNCs), and their foreign direct investment (FDI) projects in low and middle income countries (LMICs). MNCs in LMICs have been associated with unsafe or unsanitary working conditions, pollution, and aggressively marketing of unhealthy foods. This suggests a harmful impact on population health. Yet, FDI also generates employment, income, and growth, implying some benefits to population health.

FDI flows may not be the only factor determining their ultimate impact on health. It is currently unclear whether FDI into different industries or whole sectors is related to health impacts, and also whether geographic clustering of FDI is associated with an impact on population health.

The relationship between FDI and population health is investigated here, beginning with a systematic review of quantitative literature surrounding international trade and non-nutritional health outcomes. This highlights four important messages: FDI is likely a determinant of health in LMICs; the importance of sample selection and considering heterogeneity; bi-directional causality between FDI and health; and the underuse of individual level datasets to investigate the association.

Later chapters seek to respond in different ways to these messages, firstly using instrumental variable methods to investigate FDI and overall population health in LMICs. This indicates FDI to be associated with overall population health benefits, yet provides some evidence that manufacturing FDI is associated with harm. The second study utilises individual level data and spatial techniques to investigate FDI and nutritional health in Chinese adults, indicating that FDI is positively associated with increased BMI amongst Chinese adults. The final study investigates FDI and smoking in Russian adults, suggesting that FDI is associated with increased smoking.

Overall, this thesis suggests that FDI has a positive effect in general on overall health, yet is harmful when looking in more specific contexts.

Word Count

Without appendices, the word count for this thesis is 45,887 words.

Acknowledgements

I would like to thank Professors Andy Jones and Marc Suhrcke for providing a guiding hand, whilst affording me the freedom to explore the research topic for myself. This facilitated the development of my motivation, learning and subsequent ability to conduct research independently. I owe them a great deal for their patience.

I would also like to thank Dr. Shangcheng Zhou for his assistance in locating official Chinese statistics on regional mortality rates, which were not available in English. His knowledge of medical statistics originating from China was invaluable for compiling the information needed to complete Chapter 4.

I thank the University of East Anglia High Performance Computing Cluster for allowing me to utilise their equipment for the more computationally demanding procedures used, especially in Chapter 4. I learned a great deal from the team, in particular Leo Earl, to whom I owe a great debt. He encouraged me to pursue knowledge, and was always there to discuss matters of a computational nature.

I thank Dr. Yevgeniy Goryakin for joining the supervisory team part-way through the project. Our discussions on technical approaches and data sources were invaluable in the completion of the econometric analysis chapters, and I would also like him to know how much I appreciate his continuing to help once starting a new job. Finally, I would like to thank him for taking the time to assist me in translation of Russian national and regional statistics.

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Nomenclature

Abbreviation	Definition
FDI	Foreign direct investment
GDP	Gross domestic product
GDPPC	Gross domestic product, per capita
OECD	Organisation for Economic Co-operation and Development
WDI	World Development Indicators
WID	World Investment Directory
LMIC	Low and middle income country
IDCG	International development consulting group
PRISMA	Preferred reporting items for systematic reviews and meta-analyses
IMF	International Monetary Fund
MNC	Multi-national corporation
HRQoL	Health-related quality of life
OLS	Ordinary least squares regression
FE	Fixed-effects
ANOVA	Analysis of variance
IV	Instrumental variable
IVFE	Instrumental variable fixed-effects
EFI	Economic freedom index
KOF	Konjunktur-Forschungsstelle Index of Globalisation
TB	Tuberculosis
HIV	Human immunodeficiency virus
CF	Capital formation
UN	United Nations
UNCTAD	United Nations conference on trade and development
CHNS	China health and nutrition survey
RLMS	Russia longitudinal monitoring survey of HSE
CBR	Central Bank of Russia
GRP	Gross Regional Product
ZINB	Zero-Inflated Negative Binomial
BTA	Bilateral Trade Agreement
BIT	Bilateral Investment Treaty
HSE	Higher School of Economics (Russia)

Publications and statement of authorship

Publications derived from this thesis:

Burns, D.K., Jones, A.P. and Suhrcke, M., 2016. The relationship between international trade and non-nutritional health outcomes: A systematic review of quantitative studies. *Social Science & Medicine*, 152, pp.9-17.

This article can be found at `http://doi.org/10.1016/j.socscimed.2016.01.021`

Burns, D.K., Jones, A.P., Goryakin, Y. and Suhrcke, M., 2017. Is foreign direct investment good for health in low and middle income countries? An instrumental variable approach. *Social Science & Medicine.*

This article can be found at `http://doi.org/10.1016/j.socscimed.2017.03.054`

Statement of jointly authored publications

Chapter 1: Written by Darren Burns

Chapter 2: Darren Burns was the lead author of the paper published as: Burns, D.K., Jones, A.P. and Suhrcke, M., 2016. The relationship between international trade and non-nutritional health outcomes: A systematic review of quantitative studies. *Social Science & Medicine*, 152, pp.9-17.

Darren Burns led the design of the protocol and quality assessment framework, under the guidance of Andy Jones and Marc Suhrcke. Darren Burns executed the search strategy, conducted the primary and secondary screening, quality assessed the articles and drafted the original manuscript, which was then reviewed by Andy Jones and Marc Suhrcke. 10% of the primary screening was repeated by Andy Jones and Marc Suhrcke.

Chapter 3: Darren Burns was the lead author of the paper published as: Burns, D.K., Jones, A.P., Goryakin, Y. and Suhrcke, M., 2017. Is foreign direct investment good for health in low and middle income countries? An instrumental variable approach. *Social Science & Medicine.*

Darren Burns led the research, executed the data collection, cleaned the data, conducted the data analysis, and drafted the original manuscript. Yevgeniy Goryakin, Darren Burns and Marc Suhrcke consulted on the appropriate choice of instruments and methodology. Andy Jones, Marc Suhrcke and Yevgeniy Goryakin critically reviewed the original manuscript prior to submission to the journal.

Chapter 4: Darren Burns was the lead author of the paper which will be submitted as:

Regional Foreign Direct Investment and Nutritional Health in China: A Spatial Econometric Approach

Darren Burns formulated the research question, designed the econometric approach, collected the data, analysed the data and wrote the original manuscript, with some technical advice from Yevgeniy Goryakin and Andy Jones. The original manuscript was critically reviewed by Andy Jones, Marc Suhrcke and Yevgeniy Goryakin

Chapter 5: Darren Burns was the lead author of the paper which will be submitted as:

Regional Foreign Direct Investment and Smoking in Russia: A Spatial Econometric Analysis

Darren Burns formulated the research question, designed the econometric approach, collected the data, analysed the data and wrote the original manuscript, with some technical advice from Yevgeniy Goryakin and Marc Suhrcke. The original manuscript was critically reviewed by Andy Jones, Marc Suhrcke and Yevegniy Goryakin.

Chapter 6: Written by Darren Burns

CHAPTER 1

Introduction

1.1 Background to the Thesis

1.1.1 Economic Globalisation and Health

Economic globalisation is the process of countries increasing their ability or willingness to engage economically with other countries (Krugman *et al.*, 2015). The Economic aspect of globalisation is only a component of the wider concept, which changes over time, and incorporates religion, philosophy, culture, knowledge, political discourse, and many other aspects of life (Al-Rodhan & Stoudmann, 2006). Economic globalisation has often been linked with improvements in economic prosperity, which aligns with classical macroeconomic models which include interaction between one economy and other exogenous economies (Blanchard, 2006a; Krugman *et al.*, 2015). On a basic theoretical level, opening up borders to trade and reducing restrictions should be associated with increased demand for goods, and increased competition within the market for goods and services, which can then potentially lead to economic growth and increases in income levels. Yet, the reality of economic globalisation is much more complex, as is evaluating its effects. Milanovic (2003) highlights that the overall view of whether globalisation is either a positive or destructive force – even within only the economic context – is full of misconception, that even its definition is dependent on context, and that in fact both sides of this opinion (the 'two faces of globalisation') can be simultaneously correct due to the scale and complication of the process.

Within the broad range of effects which economic globalisation has lies population health. The economist Angus Deaton, in his 2004 technical report *Health in an Age of Globalization* argues that "everything is easier with money", implying that, for the poorest countries at least, economic growth – and the much-debated consequent improvements in wealth – are likely to be associated with health improvements. However, the context in which the economic globalisation takes place is an important consideration, as is its rapidity and also which industries become globalised. These factors may influence how and to what extent incomes are effected, or even completely offset the benefit which income increases may have on health. One historical example is the opium wars, in which Britain enforced economic globalisation between India and China (1839-42). Both the war itself and the subsequent globalisation are unlikely to have been associated with a net health benefit for either India or China, and therefore this instance of economic globalisation was unlikely to be associated with health benefits. Another obvious example of this is the black death in the fourteenth century, as disease spread was facilitated through the liberalisation of trade between nations (World Health Organization, 2017; Bordo *et al.*, 2007). The apparent association between economic globalisation and health raises questions surrounding causality, the mechanisms involved, and the aspects of economic globalisation which are of particular importance to health.

Critical discussion of the health implications of economic globalisation has been historically limited within the economics literature. Deaton (2004) highlights the lack of any meaningful mention of health within seminal economics texts on the history and effects of economic globalisation. For instance, Bordo *et al.* (2007) and Milanovic (2003), who write on the history of globalisation and economic development, do not reference health aside from cursory mention of privatisation or policy reform following the Great Depression. Yet, more research on the globalisation and health association has become available in recent years. In 2002, a world bank funded report by Collier *et al.* suggested that adequate health care and education provision were essential aspects of what could be termed 'successful' globalisation. In low income countries these are often not present, and this is unlikely to be resolved through exclusively economic globalisation. More recent quantitative works have attempted to elucidate what the association may be by directly investigating associations between component parts of globalisation and health or health-behavioural outcomes (Barlow *et al.*, 2017; Bergh & Nilsson, 2010; De Vogli, 2011). These have tended to conclude that economic globalisation is associated with a benefit to overall population health, yet can cause harm when looking at more specific outcomes like body mass index (BMI). Further, an article by Schrecker *et al.* (2008) rejects the notion that economic globalisation is always beneficial to health in LMICs via poverty reduction, and that often health inequities widen as a result. From the conclusions presented in the recent economics literature, the true effect of globalisation on population health can be inferred to be a mixture of positive and negative effects, and is also likely to depend on either fixed or changing factors within each individual country.

Discussions within the public health arena take a more negative view of economic globalisation and its implications for health. Increased supply and competition for, and ultimately access to and consumption of, unhealthy goods is often – and reasonably – argued to result in worsening population health (Deaton, 2004; Gilmore & McKee, 2004b). Also, important trade agreements like the General Agreement on Trade in Services (GATS) are seen to lead to an inability of low and middle income countries (LMICs) to influence the parameters of the globalisation that they are offered. This lack of flexibility limits the extent to which a country can maximise the benefit of economic globalisation to its own population, whether in terms of health or otherwise (Blouin *et al.*, 2006). For instance, GATS does not prohibit or limit the entry of foreign health service or insurance firms into new markets, which immediately creates very strong barriers to entry for potential local competitors in LMICs. This can hinder a government's ability to design its own health service, which then leads to healthcare which is not tailored to the needs of its target population (Blouin *et al.*, 2006; Smith *et al.*, 2009a). In addition to this, some works have suggested that economic globalisation facilitates advancement of medical knowledge and increase access to medical technologies, yet also causes 'brain-drains', where health (and other) professionals are presented with a wage incentive and the geographic mobility to move to a more wealthy country (Martens *et al.*, 2010). The net effect of these changes on population health is difficult to directly infer from the evidence presented to date. GATS simultaneously reduces the capacity of health services and improves access to newer and more effective – yet more expensive – health technologies. In conjunction with worsening nutritional health and increased participation in health-damaging behaviours like smoking, the negative perception within public health literature is understandable.

In summary, evidence suggests that economic globalisation is associated with a complex mixture of beneficial and harmful health implications, some of which are not yet well understood. Understanding the individual components of economic globalisation and their importance to population health, whilst also remaining mindful of the other simultaneous changes taking place, is one approach to learning about globalisation and health. Studying the association from this perspective can contribute towards achieving a process of economic globalization which can moderate and anticipate the effect it is having on people's health. Discussion papers like the one by Bettcher & Lee (2002) suggest regulation of the economic globalisation process, particularly trade (and investment) liberalisation, has the potential to take the likely associated health impacts into account. Given knowledge of the mechanisms involved and their relative importance, trade agreements and other actions enabling trade liberalisation can facilitate "healthy trade", leading to more sustainable economic globalisation process. Yet, Bettcher & Lee (2002) do caveat this, commenting that such refinements of the framework supporting international trade liberalisation must be supported by '*firm empirical evidence*'.

There has already been some quantitative research effort aiming provide such evidence. These studies tend to quantitatively investigate globalisation as a whole, using analysis of country 'roles' within the global economy (for instance, Moore *et al.* (2006), summarised in Section A.2), or by describing globalisation using numerical indices. Such scoring systems stratify economic globalisaiton into separate domains, in order to capture their respective associations with health. For instance, the Maastricht globalisation index is composed of five domains, including political, economic, social & cultural, technological and ecological (discussed further in Chapter 2). Studies using indices like these have separately concluded a mixture of beneficial and harmful associations with population health (De Vogli, 2011; Gerring & Thacker, 2008; Martens *et al.*, 2010). Taken together, it is difficult to see whether trade or economic globalisation unequivocally have a beneficial or harmful association with health. By comparison, very few studies have focused on individual parts of economic globalisation and the mechanisms by which these associations exist, whilst trying to adjust for the mediating factors of all the other contemporaneous changes taking place during globalisation (These are discussed further in Chapter 2).

1.1.2 Foreign Direct Investment

The nature of economic globalisation has been changing over time. In the last 40 years, international trade in equity – that is, investment between countries – has been increasing rapidly, from small amounts in the 1970s to a major component of economic globalisation today. Numbers of multi-national corporations (MNCs) increased, and these firms are now more engaged than ever in taking ownership of land, capital and firms in other countries. As the investment component of economic globalisation is growing, the utility of investigating its health impacts is also increasing.

When a firm acquires more than a 10% share in another firm in a different country, this is classed as 'foreign direct investment' (FDI) (OECD, 2008; World Bank, 2014). FDI flows have been monitored internationally by the International Monetary Fund (IMF) since 1970 (International Monetary Fund, 2015). Consequently, FDI has been frequently used as a means to track economic integration between countries, and the activity levels of MNCs.

FDI is often considered to be the internationalisation of a firm's primary (resource collection), secondary (manufacturing), or tertiary (service) components. This type of investment is referred to in international economics as 'vertical' FDI, in line with classic economic terminology on integration of firms (Blanchard, 2006b; Krugman *et al.*, 2015). A firm may achieve technical efficiency improvements through moving business components to countries with higher productivity, lower wage rates, or cheaper capital. As this affects labour market dynamics in recipient countries, especially those with low wage levels or high levels of unemployment, vertical FDI has been linked with economic growth generated through increased demand for labour and subsequent wage increases (Feenstra & Hanson, 1997). There has also been a lot of research interest in the potential for FDI to trigger economic growth and/or development (a transition from an agrarian to industrial to service-led economy) in low and middle income countries (LMICs) (Hansen & Rand, 2006; Moran, 2005). This is a more complex change, which involves increases in income, yet also in factors such as lifestyle, culture, health behaviours, and the environment. However, an MNC may engage in FDI for other reasons. For instance, the firm may wish to invest in a country with international trade restrictions, in order to more efficiently gain market access. This is referred to as 'horizontal' FDI, as firms must often establish all three components of their business within the destination country (Krugman *et al.*, 2015). This is because the same trade restrictions that prohibit the firm from simply exporting goods to the destination country may also limit interaction of primary, secondary and tertiary parts located in different countries. As horizontal FDI is typically an undertaking of some size, it is also likely to effect the recipient country's labour economy similarly to vertical FDI. Yet, as horizontal FDI includes all the stages of production, it is also likely to affect consumption of goods in the recipient country, as at least some finished products will be distributed within that country's consumers following production.

Finally, a firm may wish to invest in one country to gain access to an international trade network. This is referred to by Krugman *et al.* (2015) as 'platform' horizontal FDI, as the recipient country is used as a platform, or a stepping-stone, for further investment or international trade. This is typically horizontal FDI in nature, due to trade restrictions outside of the network. However, platform FDI has labour economic effects in the recipient country, yet consumer effects in the countries that ultimately consume the goods produced.

These three types of FDI are likely to have distinct developmental, consumer and labour market effects on recipient countries. However, the tracking of FDI using these classifications is somewhat under-developed internationally. Consequently, national totals of FDI are typically used in quantitative analyses, and within this thesis.

1.1.3 Potential Links Between FDI and Health

FDI could benefit health in LMICs via employment. As discussed above, new firms enter markets, creating jobs and subsequently increasing wages, leading to increases in disposable income. Some case-study evidence also suggests that MNCs, more often than not bring improvements in working conditions and production methodologies in LMICs, which may exhibit positive externalities through other firms adopting these improved practices (Jordaan, 2005; Moran, 2004, 2005). As these changes take place, population health improvements are feasible.

FDI flows to different industrial sectors within countries has been linked to economic growth in the past, with manufacturing industries in particular having demonstrated the strongest link with growth (Alfaro, 2003). This suggests that as an LMIC receives FDI, the distribution of industries making up the economy will change in favour of manufacturing industries. FDI may therefore lead to increased levels of pollution, through changes to the modes of production being employed in recipient countries (Blomström & Sjöholm, 1999). Some evidence has linked this to elevated levels of mortality amongst recipient LMIC populations through effects on water pollution (Jorgenson, 2009a,b). Horizontal FDI could also damage health through consequent changes to consumption. Some research by e.g. Hawkes (2005), Friel *et al.* (2013), Gilmore & McKee (2005), and Pomerleau *et al.* (2004) has begun to explore links between FDI and consumption of health demerit goods like cigarettes or unhealthy foods, generally finding at least some indicative evidence that FDI is associated with worsening health behaviours. Yet, as will be discussed in Chapters 2-6, no study has yet proceeded to quantitatively investigate these links using econometric methods, or has taken advantage of the large-scale individual level longitudinal health data available in several LMICs.

As will be discussed in Chapters 2 and 3, there is already some preliminary research focused on

FDI in LMICs and population health. However, this research is mixed in its suggestion of benefits, harms, and even the direction of causality between FDI and health. There is a need for research to collect and review current evidence within this context, and to subsequently investigate what the quantitatively perceptible effect may really be.

1.1.4 FDI and health within economic globalisation and health

The association between FDI and health may be mediated by other simultaneous changes. Firstly, trade and investment agreements are often prerequisites to economic globalisation, meaning FDI levels in a country do not often change whilst other aspects of economic globalisation remain constant. Barlow *et al.* (2017) present a theoretical framework, showing both FDI, trade, and other changes to all follow trade and investment agreements at the same time. Parallel to FDI, the other changes, which include trade liberalisation (and the trade which follows), intellectual property rights, and dispute settlement, lead on to a host of policy, consumption and production changes, which then all have their own knock-on effects on population health. Further, an article by Grossman & Krueger (1991) on the environmental implications of the North American Free Trade Agreement (NAFTA) suggests that factors other than FDI may also simultaneously affect pollution, which then also has its own implications for population health. Consequently, it is important to focus on the *Ceteris paribus* effect of FDI on population health, whilst remaining mindful of the possibility that the relationship is mediated by other changes taking place.

The potential effect of FDI on income levels, as discussed in Sections 1.1.2, 3.1, and 3.5, and the subsequent effects this may have on health could be mediated by consumption of unhealthy foods and health-damaging goods (e.g. tobacco) (Hawkes, 2006; Hu, 2011; Vogli *et al.*, 2014). For instance, on one hand, incomes are rising which could lead to better access to healthcare. On the other hand, the cost of food (particularly unhealthy food), or health damaging products like tobacco may be falling nominally due to trade liberalisation increasing price competition (Hawkes *et al.*, 2009; Hawkes, 2006; Gilmore & McKee, 2004b). Relatively to income, the cost of goods which ultimately harm health is therefore falling two-fold, which is likely to have implications for consumption and ultimately health on a scale which is potentially perceptible on an aggregate level.

1.2 Aims of the thesis

The general research questions in this thesis are as follows:

1. What is the current evidence base on the association between trade and health in LMICs?
2. When taking an econometric approach, what is the association between FDI and population health in LMICs?

In order to contribute to addressing these questions, a set of achievable aims have been set. These are summarised below:

1. To collect and consolidate current quantitative evidence on the association between all forms of trade and population health outcomes
2. To use this collected knowledge to develop a theoretical framework of the association between FDI and population health in LMICs
3. To explore whether an overall association between FDI and population health outcomes exists in LMICs, using econometric methods
4. To use the findings from the overall analysis to further investigate whether an association exists on a more micro-level, through utilising large-scale individual level data sources from LMICs
5. To bring the findings together, discuss the association between FDI and population health in LMICs, and reflect on the approaches taken

Quantitative evidence on FDI and population health in LMICs is sparse, and originates from several research fields (as identified in Chapter 2). The first aim is therefore to gain an understanding of what is already known about the association which FDI has with population health in LMICs. In LMICs, the beneficial and harmful influences of FDI on population health are happening alongside other economic changes, with levels of international trade chief among them. Consequently, to adequately understand the evidence to date relating to FDI and health, the utility of restricting the scope to only studies concerned directly with the association between FDI and population health is limited. Yet, thorough review of the thousands of studies concerned with globalization and health before then focusing on FDI and health in LMICs would not feasible to within the scope of a single PhD thesis. Consequently, a review is presented in Chapter 2 which considers quantitative studies of associations between international trade – in any form – and general health outcomes (e.g. mortality, life expectancy, disease prevalence). This strikes a balance between sensitivity – that is the comprehensiveness of the review in explaining economic globalisation and population health – and specificity to the focus of the thesis on FDI and health. The rationale for focusing the review on quantitative studies is that the subsequent studies are quantitatively-minded, and focusing on such studies reduces the pool of literature to consider to only that which has a direct impact on the studies which follow (Chapters 3, 4, and 5). Of course, this decision is not without consequence, as properly couching the findings within the wider literature, and inferring conclusions from the results of the quantitative studies in Chapters 3-5 requires some additional literature review (See Chapter 6 for more discussion on this).

The important issues, gaps in knowledge, and conclusions drawn from Chapter 2 then motivate three subsequent econometric analyses, which also draw from each other. Chapter 3 is focused on a more high level perspective on FDI and population health in LMICs, using a cross-country panel data analysis of 85 LMICs and focusing on aggregate FDI and population mortality rates. This incorporates an analysis of the currently available industrially disaggregated FDI data for LMICs, which provides some suggestion that factors other than the sheer amount of FDI affect the association of FDI with health. Chapters 4 and 5 focus on the issues in Chapter 2 which Chapter 3 was unable to address. These chapters also focus on nutritional health and health behaviours, to provide some breadth to the evidence within the thesis on the association between FDI and health in LMICs. Finally, the review and studies are discussed in conjunction, to draw some general conclusions on the inter-relationship between FDI and population health in LMICs.

CHAPTER 2

The Relationship Between International Trade and Non-Nutritional Health Outcomes: A Systematic Review of Quantitative Studies

2.1 Introduction

Recently, the implications of international trade, or trade in capital, goods and services between nations, to health and health systems have received considerable attention (Blouin *et al.*, 2009; Fidler *et al.*, 2009; Hawkes, 2005; Hawkes & Thow, 2008; Lee *et al.*, 2009; Walls L; Friel *et al.*, 2013). Much of this has been in the form of reports and books from international bodies, qualitative, and case-study evidence covering a broad range of possible associations between trade and health (Blouin *et al.*, 2009; Hawkes *et al.*, 2009; Smith *et al.*, 2009a,b, 2015). On the other hand, quantitative research has been chiefly focused on two areas. First has been the relationship between overall patterns of flows in international trade or Foreign Direct Investment (FDI), defined by the World Bank (2014) as the inflow of investment to acquire a lasting management interest in an enterprise operating in a different economy from the investor, and levels of international trade in health-related services (Smith, 2004; Smith *et al.*, 2009a). Secondly, some research has been focused toward associations between flows of FDI, nutrition and other health behaviours including smoking (Gilmore & McKee, 2005; Hawkes, 2005; Vogli *et al.*, 2014; Walls L; Friel *et al.*, 2013).

The empirical relationship between trade, FDI and more general health outcomes (e.g. mortality) has received comparatively little attention (Moore *et al.*, 2006; Owen & Wu, 2007). Ostensibly, this work provides a mixed picture as to whether and how trade or FDI affect non-nutritional health outcomes (referred to henceforth just as health). For instance, some evidence has indicated that greater volumes of international trade are associated with increased life expectancy, particularly in low and middle income countries (LMICs) (Owen & Wu, 2007). By contrast, other work has suggested that there is no evidence of an association when limiting countries included to those outside the Organization for Economic Co-operation and Development (OECD) (Gerring & Thacker, 2008).

Not only does there appear to be mixed evidence on the relationship itself, the topic is covered by a wide range of different research disciplines. Resultantly, there are notable differences in study setting and design throughout available empirical research. There is therefore a need to provide a systematic, comprehensive picture of the existing evidence with a focus on quantitative evidence, the limitations to understanding and future research opportunities.

Two other relevant systematic reviews currently exist. The review by Smith (2004) focuses on FDI with respect to trade in health services, whilst the other, still in the protocol stage, reviews international food-related trade policy with respect to nutritional health outcomes (Walls L; Friel *et al.*, 2013). Chapter 2 is a systematic review of quantitative evidence on the relationship between international trade or FDI and health outcomes other than those related to nutrition. Due to the nature of the evidence, Chapter 2 includes the development and implementation of a strategy to assess the meaning and quality of the heterogeneous evidence by building on previous systematic review methodologies to aid comparability and transparency. The objectives of this article are 1) to identify quantitative research on the relationship between international trade or FDI and non-nutritional population health outcomes, 2) to devise and implement a method to systematically review the literature in the context of varying inputs, methodologies and outcome measures, and 3) to highlight the most important issues raised by the literature and derive recommendations for future research.

2.2 Methods

A systematic literature search for relevant papers published up until the end of 2014 was conducted, using a set of relevant databases (SCOPUS, PubMed, EconLit and Web of Science). Grey literature was searched using Google Scholar. The search strategy was designed to capture any article using trade related, disease or health outcome terms, as well as terms pertaining to relationships between variables or statistical methodologies. Full details of the search strategy are given in Appendix A.1, and are briefly summarised here:

To be included, papers must have been published up until the end of 2014. Included papers must have included analysis of quantity, change or type of trade in relation to human public health outcome measures including disease prevalence, reported Health Related Quality of Life (HRQoL), mortality, recorded health related events including hospitalisations, or life expectancy. Articles identified as theoretical frameworks, descriptive study designs or those that did not utilise statistical data analysis to test hypotheses made were excluded. Papers discussing trade in relation to obesity, or nutritional intake were also excluded as this area was covered by the previous review, and papers focused on health behaviours were excluded (Walls L; Friel *et al.*,

Table 2.1: *Cochrane Handbook Decision aid adjusted to the review objectives*

Quality	Interpretation	Within a study	Across studies
High quality	No detected issues, or issues unlikely to seriously alter the results	high quality for all key domains	most information is from studies with high quality
Medium quality	Issues that raise some doubt about the internal validity of the study	Medum quality for one or more key domains	Most information is from studies from high or medium quality
Low quality	Issues detected seriously weaken confidence in the internal validity of results	Low quality for one or more key domains	The proportion of information from studies at low quality is sufficient to affect the interpretation of results

2013). Articles not published in the English language were excluded.

As included studies were allowed to vary by data source and analysis method, it was expected that the evidence would be heterogeneous in nature. The data extracted from each study was as follows: primary author and publication year, study aim, study design, statistical analysis method(s), exposure(s) considered, outcome measures, confounding factors controlled for, and summary results. Extracted summary results included estimated effect sizes with uncertainty measures where applicable. However, it is common in some fields to present multiple model results using different methodologies and variables. In these cases, use of a single numerical result with an uncertainty measure to describe the result of the paper could misrepresent the research. Where this was felt to be an issue, descriptive summary results were provided.

A method to systematically review the literature in the context of varying inputs, methodologies and outcome measures was devised and implemented. This was achieved using strategies derived from risk of bias assessment of clinical trials and quasi-experimental observational studies. At the time of conducting the review, no single guideline or checklist on risk of bias assessment or quality assessment was found to adequately cover the expected range of study designs. The preferred approach was therefore to develop a tool which could assess all study designs encountered. The assessment framework was based on a combination of existing guidelines and previous review protocols. These were the Cochrane Book Series (2008) Handbook for Systematic Reviews, guidance from the Collaboration (2013), guidelines from the International Development Coordinating Group (IDCG) - Campbell Collaboration (2013), and an adapted form of the IDCG guidelines used for a particular review (Baird *et al.*, 2013). These sources were utilised as they collectively covered the expected study designs. Further, their contribution to the development of the quality assessment tool helped to highlight important methodological, data and results presentation issues in studies regardless of data type, methodology or hypothesis.

The quality assessment tool is available in Appendix A.2. The five domains of assessment were data quality and collection (D1), data treatment and analysis method (D2), presentation of results (D3), post estimation testing and analysis reporting (D4) and other issues (D5). Domains were selected to cover the full range of data types, approaches, analysis methods, post estimation tests and issues with reporting in the included literature. The fifth domain was required to capture any potential matters that were unique to one research project or not captured by the other domains.

Quality assessment involved assigning a high, medium or low quality rating to each paper, with the lowest score carrying over to the overall score of the article. This approach was based on an adaption of Figure 8.7a in the Cochrane Book Series (2008) Cochrane Handbook. Similarly to the IDCG guidelines and derivatives, the assessment tool was formatted as a set of questions about the article. A judgement was made in each domain based on answers and any other relevant issues detected. Once each study was examined, an adapted form of Figure 8.7a from the Cochrane Book Series (2008) Cochrane Handbook was used as a decision aid to make judgement of overall quality (Table 2.1). As a final check of consistency, 10% of abstracts were re-screened by one other author and discrepancies in this were discussed before making adjustments.

An initial scoping review of studies suggested that heterogeneity in study designs and outcomes reported rendered it inappropriate to attempt a formal meta-synthesis. Therefore, a narrative analysis of the common themes, results and inferences made was conducted.

2.3 Results

2.3.1 Study selection and grouping of evidence

Application of the search strategy yielded a total of 15,037 results after removal of duplicate titles. The titles of all these papers were reviewed [D. K. Burns] and 405 papers were put forward for abstract or full paper screening. Once the inclusion and exclusion criteria were applied, 16 papers were accepted for review. Figure 2.1 summarises the paper screening process. The 16 included studies varied significantly in study design, study setting, and the variables being analysed (Table 2.2). However, the range of publication years was narrow. All articles were published between 2006 and 2013.

The differences between articles led to the separation of the evidence into three internally more homogeneous categories. Firstly, three studies investigated the relationship between international trade and health using individual level data and these formed Group 1 (Cross *et al.*, 2009b,a; Kawachi, 2008). Three studies were included in Group 2. These studies included data at country level, but included only countries selected in order to highlight a specific issue or test the effect of a discrete event (Bozorgmehr & San Sebastian, 2014; Gustafsson & Ramstedt, 2010; Oster, 2012). Finally, the remaining 10 studies used a global panel or cross sectional data, and formed Group 3

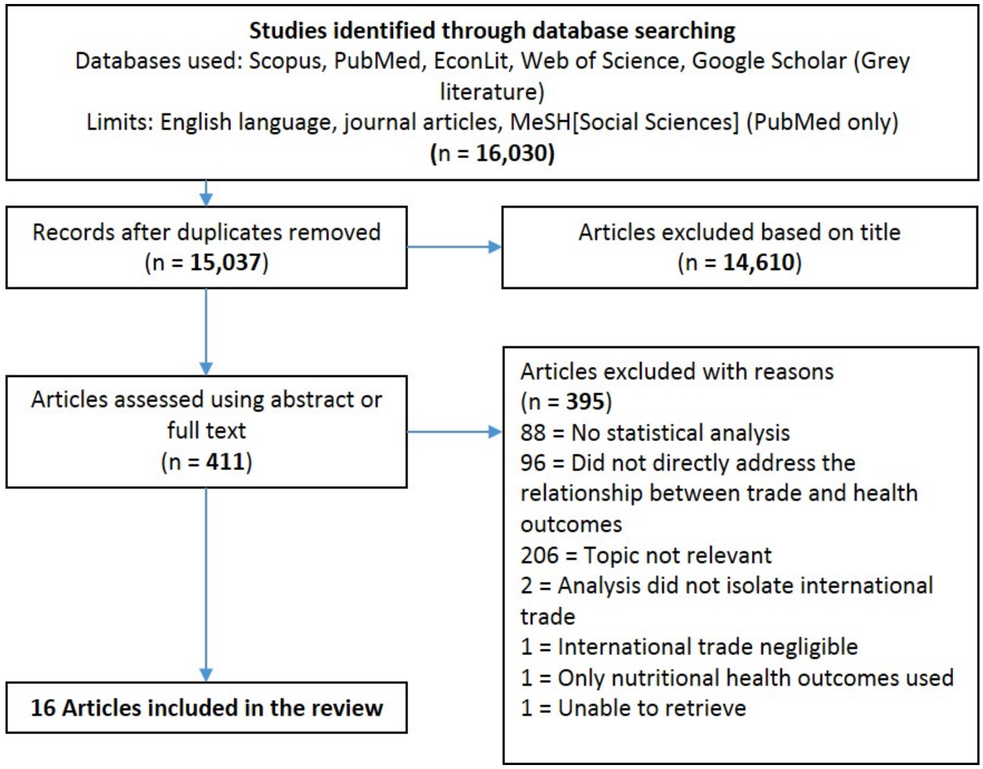


Figure 2.1: *PRISMA diagram for systematic literature retrieval process*

(Alsan *et al.*, 2006; Desbordes & Azémar, 2009; Bergh & Nilsson, 2010; Gerring & Thacker, 2008; Jorgenson, 2009a,b; Levine & Rothman, 2006; Martens *et al.*, 2010; Moore *et al.*, 2006; Owen & Wu, 2007). Four of these included only LMICs, and the other six included globally representative sets of countries from all income categories.

2.3.2 Review of evidence

Below is provided a brief narrative synthesis of the body of literature reviewed, combined with a concise commentary on quality assessment of the articles. More detailed information on the evidence is available in the data extraction table (Appendix table A.2).

Individual level data analyses (Group 1)

Two studies by Cross *et al.* (2009b,a) used primary data to compare the reported HRQoL of wealthy European countries' horticultural workers with that of workers producing goods for export in African countries (Studies 1 and 2 in Table 2.2). The primary analysis method in both was a combination of t-tests and ANOVA. Both studies also used Ordinary Least Squares regression (OLS) to determine whether confounding was an issue. The first study by Cross *et al.* (2009b) found that workers producing entirely for export horticulture in Kenya had significantly higher reported HRQoL than those in European countries, suggesting a beneficial statistical association between international trade and health. The second study by Cross *et al.* (2009a)

Table 2.2: *Summary table for study quality assessment*

Article	Study	Group (D1)	Data (D2)	Method (D3)	Results (D4)	Analysis (D5)	Other	Overall
Cross 2009b	1	1	L	M	H	H	N/A	L
Cross 2009a	2	1	M	M	M	M	N/A	M
Kawachi 2008	3	1	M	H	H	M	N/A	M
Bozorgmehr 2014	4	2	H	H	H	H	N/A	H
Gustafsson 2010	5	2	H	H	H	H	H	H
Oster 2012	6	2	H	H	H	H	N/A	H
Alsan 2006	7	3	H	H	H	H	N/A	H
Bergh 2010	8	3	M	H	H	H	N/A	M
Desbordes 2009	9	3	H	H	H	H	H	H
Jorgenson 2009a	10	3	M	H	H	H	N/A	M
Jorgenson 2009b	11	3	M	H	H	H	N/A	M
Levine 2006	12	3	H	H	H	H	N/A	H
Martens 2010	13	3	H	M	M*	H	N/A	M
Moore 2006	14	3	H	H	H	H	H	H
Owen 2007	15	3	H	H	H	H	N/A	H
Gerring 2008	16	3	H	H	H	H	H	H

*Quality in this domain was only with respect to the topic of this review
Judgements: L = Low study quality. M = Medium study quality. H = High study quality
Groups: 1 = Individual level data analyses. 2 = Selected country analyses.
3 = International panel analyses.

supported this evidence when comparing Ugandan agricultural workers with those of the UK. Both works also suggested that the relationship between export horticultural work and HRQoL was clearer in African samples. However, quality assessment identified the two studies as providing low and medium quality evidence respectively, based on quality of data, method and inference (D1, D2 and D4). Recruitment was not standardised in the different groups considered, raising the suspicion that the evidence was heterogeneous by location. Further, the HRQoL surveys used (chiefly the SF36) were not designed based on the health perceptions of African populations. As these surveys have not been used to establish population norms in African countries, and tests of consistency between African and European populations have not been carried out, it is unknown whether this had an impact on the internal validity of the study. Population norms for the USA were used in both studies in an attempt to find a common comparator. However, it is not unreasonable to suggest that US health perceptions more closely resemble those of Europeans, raising the possibility of an unreliable point of comparison. The study designs of both studies were not considered to adequately adjust for the heterogeneity discussed above (D2). Further, Ordinary Least Squares (OLS) was used to establish the associations between HrQoL and a set of confounding variables, yet the final study design did not adjust for their confounding effects. Cross *et al.* (2009b,a) therefore presented relatively weak evidence that international trade, or labour in periphery to international trade was related to improved worker health in African countries.

Kawachi (2008) used individual level data from the Korean Labour and Income Panel's 4th wave in 2001 to construct a propensity score matching estimator for poor self-reported health by workers under either full time or flexible work contracts (Study 3).Kawachi argued that globalisation and trade openness were associated with increases in the prevalence of flexible contracts. Results indicated that those with flexible contracts were approximately 1.5 times more likely to report poor health than others with matched characteristics. The quality of the evidence provided was assessed as medium based on the relatively small sample and very brief data description (D1), post-estimation testing and inference (D4). Overall, the study provided fairly robust evidence of an indirect harmful association between trade openness and the health of workers in South Korea in 2001.

Selected country panel analyses (Group 2)

The three selected country analyses differed in study design and setting. Bozorgmehr & San Sebastian (2014) used data from 22 high Tuberculosis (TB) prevalence countries between 1990 and 2010 to examine evidence for a relationship between economic globalisation and TB incidence. OLS, fixed effects and random effects models were used for the analysis in order to both provide comparable results, and adjust for unobserved heterogeneity. In most models, no association was found between measures of economic globalisation (the recently developed Swiss Institute of Technology (2014) Konjunktur-Forschungsstelle Index of Globalisation (KOF), economic domain (KOF1), and the Berggren & Jordahl (2005) Economic Freedom of the World index (EFI) Freedom to Trade Internationally (EFI4)) and TB incidence. However, one model adjusting for time trends provided evidence that an increase of 1 point in the EFI4 was associated with a 10.4% drop in TB incidence. Increases in KOF1 were associated with a similar magnitude of decline in TB incidence. The authors concluded that no association was present between globalisation and TB incidence, and that the positive results they did find were not sufficiently reliable to infer an association.

Quality assessment indicated Bozorgmehr & San Sebastian (2014) to provide high quality evidence. The author was clear that study generalizability was limited, and no data issues were detected (D1). The range of analysis methods used was reasonable (D2), and there was no indication that any results or inference was omitted (D3, D4).

Gustafsson & Ramstedt (2010) investigated the removal of personal alcohol import quotas in Sweden Finland and Denmark, and large alcohol tax decreases in both Denmark and Finland. The outcomes considered were hospitalisations due to acute alcohol poisoning and drink driving, and arrests regarding violent assaults. Generally, no association was found between the policy changes and any of the outcomes. However, a positive association between the Swedish quota increase and hospitalisations due to acute alcohol poisoning was found in those aged 50-69. Quality assessment indicated this evidence to be of a high quality. The data used was adjusted for seasonal change and linearly interpolated across discrete events like riots (D1). The analysis method was a lagged, integrated model using year-on-year change in the variables in question, which raised no suspicions regarding internal validity issues (D2), and the results were thoroughly presented and critically discussed (D3, D4).

Oster (2012) used data from 36 sub-Saharan African countries from 1985 to 2007 to investigate whether export of goods was associated with HIV incidence. Oster hypothesised that HIV had spread via truck driving, and thus land-based export or import was one mechanism through which international trade could be associated with HIV spreading between African countries. When controlling for country and time fixed effects, a positive association was found between the amount of exports and estimated HIV incidence rates, with a doubling of exports being associated with between a 10% and 100% increase in incidence. Quality assessment indicated this evidence to be of high quality. Flaws in the data were carefully considered and discussed (D1), the analysis methodology was seen as appropriate (D2), and Oster adjusted for the effect of a range of confounding variables (D1 D2 D4).

International panel analyses (group 3)

Five studies investigated relationships between amount of, or dependency on, international trade or trade openness with respect to health (Bergh & Nilsson, 2010; Gerring & Thacker, 2008; Levine & Rothman, 2006; Martens *et al.*, 2010; Owen & Wu, 2007).

Quality assessment indicated Bergh & Nilsson (2010); Martens *et al.* (2010) as medium quality, whilst the work by Gerring & Thacker (2008); Levine & Rothman (2006); Owen & Wu (2007) were indicated to provide high quality evidence. The studies by Levine & Rothman (2006), Owen & Wu (2007), and Gerring & Thacker (2008), all used similar international panel data sources, which were felt to have a high level of geographical and temporal coverage. Owen & Wu (2007); Gerring & Thacker (2008) both used fixed effects models to adjust for unobserved heterogeneity between countries, whilst Levine & Rothman (2006) went a step further, also adjusting for suspected endogeneity, and testing the robustness of the results when using alternative globalization indices. In all three cases, the approach was considered appropriate, leading to high quality scores for both data (D1) and approach (D2, D4). Finally, none of these studies claimed to establish causal associations, and it is stated that they simply present robust evidence that non-nutritional population health tends to be better in countries more engaged in international trade.

Bergh & Nilsson (2010) dropped a significant proportion of their panel to conduct the primary analysis, and this was felt to affect the quality of the data due to a lack of international representativeness (D1). However, in all other aspects the evidence was felt to be of a high quality. Martens *et al.* (2010) was judged to have issues affecting internal validity relating to the choice of analysis method, presentation of results and robustness checking (D2, D3 and D4). The analysis method was cross-sectional OLS, and there was no reference to unobserved heterogeneity in the data from different countries, raising suspicions of biased estimation. Further, the choice to present only bivariate regressions for the individual effects of index domains was an issue with results presentation (D3), but only with respect to this review which is chiefly concerned with the 'economic globalization' domain. finally Martens *et al.* (2010) does not test whether using an alternative globalization index led to similar results. Comparison between globalisation indices was considered to be an important robustness check, and other work has highlighted the importance of this (D4) (Zinkina *et al.*, 2013).

Moore *et al.* (2006) investigated the relationship between 'world system role' and infant mortality, finding some evidence of a harmful association. These roles were allocated to countries satisfying criteria relating to international trade levels, economic globalization and industrial composition of production. The analysis used dummy variables for allocated roles, controlling for geographical and other confounding variables to provide evidence for an association between the type of international trade a country is engaged in and population health. This indicated that 'periphery', or highly specialised and foreign capital dependant countries also had higher levels of infant mortality when controlling for confounders. This article focused on stating the importance of context when investigating international trade and population health, rather than demonstrating particular causal mechanisms through which trade may affect health. Quality assessment indicated this to be high quality evidence. One issue was the choice of an OLS estimation method, yet this was felt to be appropriate considering the necessity to use time invariant dummy variables to capture the 'world system role' (D2). Unobserved heterogeneity was possibly an issue in the results, but internal validity was unlikely to be seriously compromised by this due to the large samples and geographical control variables used.

Four studies either analysed links between FDI and health through a proxy of water pollution, or analysed the effect of health in one year on FDI inflows in subsequent years (Alsan *et al.*, 2006; Desbordes & Azémar, 2009; Jorgenson, 2009a,b). The articles by Jorgenson (2009a,b) are two similar analyses utilising fixed-effects regression to reveal a significant positive association between FDI in secondary sector industries and water pollution in Low and Middle Income Countries (LMICs).

The final two studies, by Alsan *et al.* (2006); Desbordes & Azémar (2009) both used international panels representative of LMICs, and included a range of important confounding variables, leading to a score of high quality in the data domain (D1). The two studies primarily utilised fixed effects estimation also including time dummy variables to adjust for both time specific effects and country specific effects. This was a reasonable approach (D2). Both studies provided a list of countries included, discussed extensively the confounding variables included, and suitably cautioned the interpretation of their results (D3 and D4).

2.4 Discussion

2.4.1 Summary of results

The majority of articles included in this systematic review indicate that countries with higher levels of international trade also appear to have better population health. However, the direction and magnitude of this association did vary with the study design, the geographic scale and whether the research focused on international trade in general, or international investments.

In seven out of ten global panel analyses, evidence was provided to suggest that countries with higher levels of international trade, FDI inflows or higher scores on globalisation indices had better population health when adjusting for confounding factors. This evidence was considered to be generally reliable as most of these studies presented high quality evidence. In Group 2 studies, the associations between trade and health were less clear, yet the evidence remained of a generally high quality. Two studies found no association between trade and health overall, and the third study provided evidence of one channel through which international trade could be linked with the spread of communicable disease. Finally, Group 1 studies provided evidence of a generally lower quality and did not provide a clear message. Cross *et al.* (2009b,a) provided very weak evidence of labour working for internationally trading firms also having higher HRQoL, while Kawachi provided medium quality evidence to suggest that people working in jobs typically associated with globalised economies have inferior health.

This evidence remained somewhat mixed when only considering high quality studies, though the majority of those studies still found beneficial associations. Moore *et al.* (2006) reported the potential for a harmful association between international trade and health and Oster (2012) indicated that the spread of disease between countries in Africa could be related to the export of goods.

Studies indicating harmful associations between trade, or alternatively FDI, and health generally used more specific study settings to those finding only beneficial effects. Five of six studies with the most generalizable study setting, global panels of as many countries as data would allow, indicated a beneficial relationship between levels of trade or FDI and health (Bergh & Nilsson, 2010; Gerring & Thacker, 2008; Levine & Rothman, 2006; Martens *et al.*, 2010; Owen & Wu, 2007). On the other hand, evidence from articles including only LMICs more often reported mixed results, but research indicating harms was limited to the impact of FDI (Jorgenson, 2009a,b). Studies selecting countries based on disease prevalence or discrete policy change criteria tended to either find no association, or harmful health associations only in specific demographic groups (Bozorgmehr & San Sebastian, 2014; Gustafsson & Ramstedt, 2010). Finally, individual level data analyses, which also tended to have the most specific study settings, showed mixed results, and were also generally of a lower quality (Cross *et al.*, 2009b,a; Kawachi, 2008).

When consolidating the evidence, mixed findings may have been partially due to variation in study setting, study design and input/output variables considered. Despite the heterogeneity in the findings, four messages stood out as potentially usefully informing future work. Firstly, the importance of foreign direct investment as a potential determinant and consequence of health; secondly, the role of sample stratification in affecting the estimated relationship between trade and health in international panel studies; thirdly, the importance of considering mutual association when analysing the trade or FDI and health; and finally, the surprisingly limited use of individual level data. The following sub-section briefly discusses each of these issues.

2.4.2 Review of selected key issues raised by the included literature

FDI is likely to be a determinant of non-nutritional health, but current evidence is unclear

Alsan *et al.* (2006), and Desbordes & Azémar (2009) found statistically significant associations between health and future FDI inflows, whilst Jorgenson (2009a,b) associated FDI in the secondary sector to health outcomes via environmental impact in LMICs. Research using globalisation indices also hinted at a relationship between FDI and health.

High quality evidence suggested that investment flows between countries were affected by health, but evidence suggesting the reverse was constrained by data limitations. Four articles focused their analyses on FDI, rather than international trade in general (Alsan *et al.*, 2006; Desbordes & Azémar, 2009; Jorgenson, 2009a,b). Alsan *et al.* (2006) and Desbordes & Azémar (2009) provided high quality evidence suggesting that population health affected FDI levels in LMICs. Jorgenson (2009a,b) provided medium quality evidence of an indirect but harmful association between FDI and mortality. All four of these studies used panel data representative of LMICs.

Bergh & Nilsson (2010), Bozorgmehr & San Sebastian (2014), Martens *et al.* (2010) did not use FDI data directly. Instead they used composite measures of economic globalisation, derived from a combination of FDI, trade and policy data. Although two of these studies found beneficial associations between the index they used and population health, thereby suggesting the importance of FDI, it was not possible to identify the effect of FDI from the rest of the information used to calculate the index.

The nature or purpose driving investment was also identified as a common theme in the evidence included. Jorgenson (2009a,b) analysed FDI specifically into secondary industries, suggesting that FDI in these industries was more likely to be associated with harms to population health. Moore *et al.* (2006) also highlighted the importance of investment orientation. Countries fulfilling criteria to be allocated to a 'periphery role' were also primarily recipients of secondary sector FDI. These countries saw higher infant mortality figures, and it was suggested that perhaps these two factors were related. Finally, Alsan *et al.* (2006) suggested that the motives driving FDI were a key consideration: the large majority of FDI entering rich industrial countries was to access their markets, rather than for other reasons like manufacturing for export. Alsan *et al.* (2006) argued that within LMICs, which typically see a larger proportion of primary and secondary sector FDI, the association between population health and levels of investment was likely to be stronger.

Sample selection affects the relationship

The message from this set of evidence was that stratification of countries was important in highlighting important nuances in the relationship between international trade and health. However, two studies indicated that to conduct stratified analysis by income alone may not be sufficient. Instead, research should also look to the nature of the goods being imported or exported, and also the nature (i.e. industry or intention) of international investments.

Four studies used stratified analysis, and the primary analysis in another was based on separating countries into separate groups based on international trade criteria (Alsan *et al.*, 2006; Bergh & Nilsson, 2010; Moore *et al.*, 2006; Owen & Wu, 2007). Owen & Wu (2007) provided high quality evidence of a beneficial relationship between trade and life expectancy when only including LMICs, but no such association among high income countries was found. Despite there being many differences between FDI and international trade, a similar pattern was found by Alsan *et al.* (2006) when looking at the relationship between FDI inflows and life expectancy. However, Gerring & Thacker (2008) conducted stratified analysis using membership to the OECD, finding no association between international trade and infant mortality in a sample of non-OECD countries.

Bergh & Nilsson (2010) and Nilsson repeated the primary analysis many times, changing the inclusion criteria each time. The country with the highest GDP per capita would be excluded with each iteration. Their results were collated and graphed to give a visual representation of the effect of GDP per capita on the relationship between economic globalisation and health. Generally, the KOF1 index was positively associated with life expectancy. However, when the panel was reduced to mostly lower-middle GDP per capita countries, this relationship appeared to break down. This suggested that there existed a particular income level at which the relationship between trade and health was non-existent, or even harmful.

Finally, Moore *et al.* (2006) revealed a group of eight countries (Kazakhstan, Kenya, Mauritius, Namibia, Senegal, Sri Lanka, Trinidad and Tobago, Zimbabwe) with a potentially harmful association between international trade and mortality, seemingly in concurrence with the continuous stratification approach of Bergh & Nilsson (2010). This analysis, along with the model excluding OECD members presented in Gerring & Thacker (2008), highlighted the importance of factors other than national income to the relationship between the trade and non-nutritional health. For example, position in the global supply chain, the industries operating within the country, or membership to a global trade network.

The link between trade or FDI and health may be bi-directional

Twelve articles provided a medium to strong indication of international trade affecting health.

Some of these at least considered the possibility of reverse causality, but adjustments for this were typically crude.

Four studies explicitly raised concerns about endogeneity in their models of trade or globalisation affecting non-nutritional health, caused, for instance, by reverse causality (Bergh & Nilsson, 2010; Gerring & Thacker, 2008; Levine & Rothman, 2006; Owen & Wu, 2007). Bergh & Nilsson (2010), and Gerring & Thacker (2008) used lagged explanatory variables to reduce endogeneity bias without exploring the possibility of a two way association, whereas Levine & Rothman (2006), and Owen & Wu (2007) used study designs that were more robust to endogeneity. Levine & Rothman (2006) used instrumental variables regression to adjust for endogeneity in their primary analysis. International trade as a percentage of GDP was instrumented by the estimated trade to GDP ratio based on the 'gravity model' proposed by Frankel & Romer (1999).

Owen & Wu (2007) tested for reverse causality in an arguably somewhat crude way, i.e. by simply repeating the primary fixed effects regression analysis of trade openness versus life expectancy, but in reverse. Taken literally, the results indicated that lagged adult life expectancy was not generally significantly associated with trade openness in that direction, but was associated with the import of medical goods and their relative prices. Since these two pieces of evidence were concerned with different health outcomes, they did not entirely contradict one another. However, it remains that only a small number of studies have attempted to actually explore the idea of a mutual association between trade and non-nutritional health. Future research should seriously consider the possibility of endogeneity in order to avoid presenting biased and possibly misleading results.

There is evidence for FDI affecting health, health affecting FDI, and some evidence indicating an interrelationship between communicable disease and FDI. The studies by Alsan *et al.* (2006), and Desbordes & Azémar (2009) provided high quality evidence to suggest that mortality was significantly negatively related to future inflows of FDI in LMICs. Conversely, the works by Jorgenson (2009a,b) were also focused on FDI in LMICs, and provided medium quality evidence of a significant harmful association between lagged secondary sector FDI and infant mortality rates. Further, Desbordes & Azémar (2009) went on to discuss possible endogeneity, yet only between health and income or health and education within the context of the association between HIV prevalence and FDI inflows. Overall, this evidence suggested that FDI and health could be interrelated, but to date there is no empirical evidence to explicitly demonstrate this. Future work on the relationship between FDI and health should try to more specifically examine potential reverse causality.

Individual level data analyses were scarce and had data related limitations, yet still provided important results

Just three of fifteen studies made use of individual level data (Cross *et al.*, 2009b,a; Kawachi, 2008). Cross *et al.* (2009b,a) focused exclusively on the health of those employed in export horticulture, whilst Kawachi (2008) investigated workers under flexible work contracts, typically associated with economies heavily engaged in international trade. The shortage of individual level data analyses in this field may be related to the difficulty of obtaining appropriate data, particularly in LMICs. Even when conducting primary data collection as Cross *et al.* (2009b,a) did, data quality issues were present due to the inconsistency of data collection for different populations around the world.

Individual level evidence was — as it should be — highly specific to the populations being analysed. Kawachi (2008) associated flexible work contracts with economic globalisation, and this may or may not have been the same for any other country in the world. However, the use of labour survey data also increased the depth with which Kawachi could analyse the South Korean working population. The same specificity to the populations assessed was also true of Cross *et al.* (2009b,a). Of course, this limited level of generalizability was noted by authors of all three studies. Overall, these studies provided original insight into aspects of the international trade and health relationship that could not otherwise be detected.

2.4.3 Review of strengths and weaknesses

This is, as far as it is possible to establish from published literature, the first review with a particular focus on quantitative evidence of international trade affecting non-nutritional outcomes. Heterogeneous evidence covering various study designs, settings and included variables was assessed. Study designs ranging from individual level to country-level global panel analyses were all taken into account during the review and quality assessment processes. A quality assessment tool was developed to encompass this range. This was quite specifically targeted for the literature reviewed in Chapter 2. Use of this tool facilitated the identification of key issues in terms of sensitivity of the results, and recommendations for future research.

A weakness of this study include the lack of quantitative meta-synthesis. This was primarily due to the heterogeneity of the reviewed evidence which precluded the use of the method. Further, the search strategy limited the inclusion of papers to the English language. A (likely) small share of potentially relevant evidence may therefore have been missed. Thirdly, the separation of the evidence into three groups due to lack of comparability, although deemed to be necessary to derive important messages, illustrated the extent of heterogeneity in the evidence being assessed. Finally, there is a wealth of theoretical, descriptive, qualitative and case-study evidence on relationships between international trade and health which were outside the scope of the inclusion criteria (Blouin *et al.*, 2009; Fidler *et al.*, 2009; Gerring & Thacker, 2008; Hawkes & Thow, 2008; Hawkes *et al.*, 2009; Lee *et al.*, 2009; Smith *et al.*, 2009a,b). Other types of evidence are unquestionably of importance to understanding the association between trade and population health. However, systematically retrieved and quality assessed quantitative evidence on the topic is deliberately presented here. It is believed that consideration of evidence from a quantitative perspective is useful in itself, has provided an original insight into the issue, and highlighted several important questions for future research.

2.4.4 Suggestions for future research and policy implications

First, there is scope for more research on the relationship between FDI and health outcomes. As discussed, there already exists evidence from several studies to suggest that health affects FDI inflows (Alsan *et al.*, 2006; Desbordes & Azémar, 2009), that FDI in secondary industries affects infant/child mortality through its effect on water pollution (Jorgenson, 2009a,b), and that the intention and nature of FDI affects how it might impact on health outcomes (Alsan *et al.*, 2006; Jorgenson, 2009a,b). It may be particularly worthwhile to examine whether the FDI and health relationship differs by health outcome considered (e.g. adult health vs. child health), by the specific industries the FDI is targeting, and by geographical concentration of FDI.

Second, better testing and controls for endogeneity between trade, or alternatively FDI, and non-nutritional health would provide useful insights into the true nature of the relationship between the two. Third, two papers indicated that there may exist a subset of countries with an apparently different relationship between international trade or economic globalisation and health from other countries, even when controlling for major confounders like income (Bergh & Nilsson, 2010; Moore *et al.*, 2006). Research to establish the reasons for this is therefore recommended, including understanding the importance of not only quantity or rules surrounding trade (or FDI), but the composition of it as well.

Fourth, quantitative data analysis on non-nutritional health impacts of trade agreements, trade relations or trade politics was not found. Indeed, only Gustafsson & Ramstedt (2010) analysed discrete trade policy changes of any kind in relation to non-nutritional health outcomes. Quantitative research on this topic could reveal that not only the quantity of trade is important to its association with health.

Fifth, there is scope for quantitative data analyses forecasting the potential future impact of trade on non-nutritional health outcomes (and vice-versa). All of the included evidence had a focus on establishing the existence of relationships observed in past data, rather than attempting to estimate the future impacts.

Finally, more individual level analysis on this topic is recommended. The studies by Cross *et al.* (2009b,a) lacked consistency in the data being collected by different institutions, and this led to significant limitations in the resulting evidence. Future research on an individual level should focus on ensuring the quality and consistency of the data being collected. Such a study could isolate particular exposures as particularly damaging or beneficial.

2.4.5 Policy implications

Public health policy makers and advocates need to be aware that international trade may affect a broad range of health outcomes, well beyond the specifically nutrition-related ones that have been the focus of much of the ‘trade & health’ literature so far. While overall, trade appears to entail beneficial health effects, there remain examples in various studies of potential adverse health effects, including the spread of infectious disease and increases in pollution resulting in mortality increases amongst children. What follows from the mixed evidence is that relevant institutions (such as the UN or World Bank) need to at least monitor and seek to assess the health impact of trade policies. Should harmful effects be identified (or predicted), policies need to be considered to mitigate or prevent such adverse effects. Finally, healthier countries, particularly healthier countries within sub-Saharan Africa, have been shown to attract more FDI than the less healthy (Alsan *et al.*, 2006; Desbordes & Azémar, 2009). Policymakers seeking more FDI, with the likely positive economic effects commonly associated with it, might reasonably see this is as an additional incentive for increasing efforts to improve population health.

2.5 Summary so Far

In summary, this chapter highlighted the potential importance FDI and health. This association is likely to be particularly important in LMICs, could run in both directions, and could also be sensitive to the industrial composition of FDI. Yet, there is currently a sparsity of quantitative evidence to support the idea that FDI has any effect on population health in LMICs, particularly when taking these factors into consideration. Chapters 3, 4, and 5 therefore investigate the association between FDI and health in LMICs.

Chapter 3 focuses on the FDI and health association in LMICs, using the most generalisable setting. FDI and its association with mortality in LMICs is investigated in the cross-country context, using data from as many relevant countries as possible, and across the longest time-span for which data is available. The possibility that the FDI and health association depends on FDI industrial composition is also explored to the extent which current data will allow. This investigation provides — for the first time for LMICs — endogeneity robust evidence of an association between FDI and health, and provides some preliminary evidence of the role which industrial composition may have.

This investigation provides — for the first time for LMICs — endogeneity robust evidence of an association between FDI and health, and provides some preliminary evidence of the role which industrial composition may have.

CHAPTER 3

Is Foreign Direct Investment Good for Health in Low and Middle Income Countries? an Instrumental Variable Approach

3.1 Introduction

As identified in Chapter 2, one important macroeconomic determinant of health could be FDI (World Bank, 2014). FDI is widely acknowledged to promote economic growth, increases in wages and generally improved working conditions in low and middle income countries (LMICs) (Blouin *et al.*, 2009; Feenstra & Hanson, 1997; Moran, 2004). As these factors could affect access to healthcare, especially in LMICs where access to care is strongly dependent on ability to pay, it may be the case that FDI is beneficially associated with population health. Yet conversely, FDI may also have adverse effects on health, through channels like pollution or changing health behaviours (Hawkes, 2005; Jorgenson, 2009a,b).

For example, there is a considerable body of work suggesting links between FDI and consumption of tobacco or unhealthy foods, rising levels of harmful pollution, and increasing over-nutrition, all of which directly harm population health (Gilmore & McKee, 2005; Hawkes, 2005; Jorgenson, 2009a,b; Labonté *et al.*, 2011). This suggests a complex and ex-ante ambiguous overall relationship between FDI and health in LMICs. Just three articles to date have quantitatively investigated the health impacts of FDI in LMICs. As noted in section 2.3.2, two very similar studies by Jorgenson (2009a,b) focus on FDI into secondary sector industries (See Table 3.1), and levels of water pollution using panel analysis of annual data from 30 countries. Their results suggest that secondary sector FDI is associated with elevated pollution, which in turn increases infant and child mortality. Another study, by Alam *et al.* (2015) investigated the effect of FDI and international trade on life expectancy, using annual time-series data from Pakistan. Results from vector error correction models indicated that in Pakistan, increases of

FDI were associated with both short and long-term benefits to life expectancy.

Whether the findings from these studies extend to LMICs in general is yet to be rigorously tested. This is addressed through empirical investigation of the overall impact of FDI on health, with health being proxied by a set of general population health indicators. Additionally, as the studies by Jorgenson (2009a,b) raised the possibility that industrial composition of FDI affects its association with health, Chapter 3 also begins to further unpack the role of FDI by exploring the potentially specific, differential health impacts resulting from different types of FDI. To achieve this, FDI to LMICs was disaggregated into investments into primary, secondary, and tertiary industries, as defined by the United Nations Conference on Trade and Development (UNCTAD). For a summary of these industrial classifications, please refer to Table 3.1.

In empirically assessing the impact of FDI on health, it is important to acknowledge the likelihood that there is a reverse impact running from health to FDI inflows in LMICs, as discussed in Section 2.4.2 and described in Figure 3.1. As Alsan *et al.* (2006) argue, health affects the human capital of the workforce, and consequently productivity. If this is the case, then this relationship leads to LMICs with better population health subsequently receiving more FDI. The authors report some empirical support for this, in the form of regression analysis of life expectancy and FDI inflows in 85 LMICs. Since then, empirical studies of health influencing FDI have generally supplemented evidence for healthier LMICs receiving more FDI, using similar methods and panel datasets (Asiedu *et al.*, 2015; Desbordes & Azémar, 2009; Ghosh & Renna, 2015).

If the FDI and health association is truly bi-directional, regression analyses failing to take this into account will be biased by so-called 'endogeneity', meaning that FDI will be correlated with the error term, leading to an erroneous estimated coefficient and standard error (Gujarati & Porter, 1999; Gujarati, 2009). To adjust for this issue and the misleading results it can lead to, an exogenous determinant of FDI inflows which is not related to population health (see Figure 3.1) is required. In this Chapter, therefore, the existence of a causal relationship between FDI and population health in LMICs is investigated, whilst explicitly taking endogeneity into account using a novel instrumental variable (IV) regression approach.

The evidence presented in Chapter 3 suggests that after explicitly adjusting for endogeneity, FDI is weakly associated with a marginal benefit to overall life expectancy in LMICs, yet more closely associated with adult mortality. Some weak preliminary evidence of secondary sector FDI harmfully impacting upon health in LMICs is also found.

3.2 Data

Table 3.2 lists the data sources and descriptive characteristics of all the variables used. Sections 3.2.1 to 3.2.3 briefly comment on the population health, FDI and factors influencing both FDI

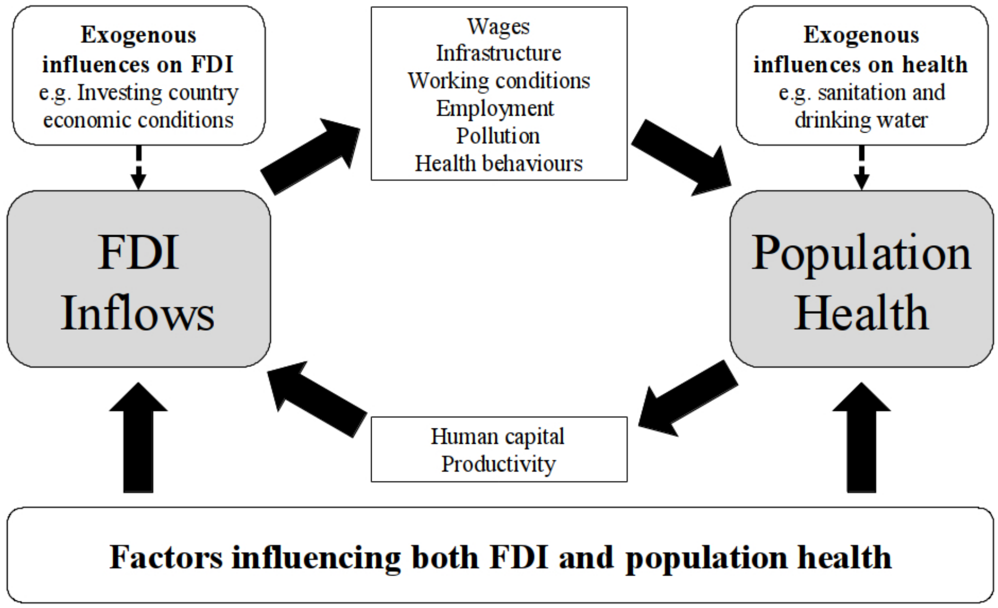


Figure 3.1: *Theoretical Framework of FDI and Population Health Association in LMICs*

and health cells in Figure 3.1. To investigate whether FDI is related to overall health in LMICs, annual panel data from 85 LMICs, over the period 1974-2012 was used. Countries were categorized as LMICs based on the World Bank, (2015a) classification of income and lending groups. Information on countries included in the analysis is available in Appendix tables B.1 and B.2.

Whether or not the industrial decomposition of FDI was related to health was investigated using panel data from a subset of 31 LMICs 1987-2008 (see Table 3.1). Except for FDI data, both the overall and sectoral analyses utilized the same data sources.

3.2.1 Outcome Variables

Life expectancy at birth, as reported in the World Bank, (2015b) World Development Indicators (WDI) was used as a primary measure of overall population health because it was the most encompassing measure which was also widely available for LMICs. Measures incorporating both length and quality of life are preferable, but were unavailable for a large number of countries and years. Other health outcome variables were used to investigate the relationship between FDI and health in different age groups, and these included infant, under-five and adult mortality rates.

3.2.2 Predictor Variables

Foreign investment was measured using data on FDI inflows to LMICs taken from the UNCTAD bilateral investment database, as is common in research within this context (Ghosh & Renna, 2015; UNCTAD, 2014). Although it has been suggested that aggregate FDI inflows are unlikely to fully account for multinational corporation activity, FDI is the only measure which is available for most LMICs over longer time periods (Lipsey, 2008).

Data on the sectoral breakdown of FDI inflows to LMICs was combined with data on total FDI inflow to calculate the proportion of total FDI made up of primary, secondary or tertiary sector investments. The exact assignment of industries to are defined within the world investment directory publications, see table 3.1 below (UNCTAD, 2003, 2004, 2008). This 'industrial concentration' measure originated from two sources; several editions of the UNCTAD (2003, 2004, 2008) world investment directory, and the China statistical yearbook, as taken from the National Bureau of statistics of China (2014).

The world investment directory includes sectoral FDI data from many LMICs, but no data on FDI to China. China has received large quantities of FDI since the early 1990s. Annual data on FDI inflows by industry to China are publicly available, and Chinese FDI data was therefore included in the sectoral analysis. To test whether including this data affected the results, models omitting China were also estimated and compared to those including the full sample.

3.2.3 Other covariates

Gross Domestic Product per capita

The association between FDI and population health is likely to be confounded by a country's economic conditions. Gross domestic product per capita (GDPPC), a widely available and commonly used proxy measure for economic conditions was included in all estimations (Blonigen *et al.*, 2007; Moore *et al.*, 2006). LMICs with a higher GDPPC were expected to both receive larger FDI inflows and have better population health. Finally, as discussed further in Section 3.3.2, countries in better economic situations are more likely to have higher FDI outflows, suggesting that the inclusion of GDPPC for the 85 LMICs included in the regression sample improves the validity of the instrumental variables.

Education

Evidence suggests that countries with higher human capital receive more FDI, and have better population health (Noorbakhsh *et al.*, 2001; Veenstra, 2002). Education is a commonly used proxy measure for human capital, and is also associated with population health (Antrás *et al.*, 2015; Daude & Stein, 2007) (Chapter 2). The most widely used measures are school enrolment, years of education, and secondary education graduation (Alsan *et al.*, 2006; Barro & Lee, 2013).

Table 3.1: *World Investment Directory Industrial Disaggregation of FDI*

World Investment Directory Category	ISIC V4 Code
Primary	
Agriculture, hunting, forestry and fishing	01, 02, 05
Mining, quarrying and petroleum	10,11,12,13,14
Secondary	
Food, beverages and tobacco	15,16
Textiles, clothing and leather	17,18,19
Wood and wood products	20,21
Publishing, printing and reproduction of recorded media	22
Coke, petroleum products and nuclear fuel	23
Chemicals and chemical products	24
Rubber and plastic products	25
Non-metallic mineral products	26
Metal and metal products	27,28
Machinery and equipment	29
Electrical and electronic equipment	30,31,32
Precision instruments	33
Motor vehicles and other transport equipment	34,35
Other manufacturing	36
Recycling	37
Tertiary	
Electricity, gas and water	40,41
Construction	45
Trade	50,51,52
Hotels and restaurants	55
Transport, storage and communications	60,61,62,63,64
Finance	65,66,67
Business activities	70,71,72,73,74
Public administration and defense	75
Education	80
Health and social services	85
Community, social and personal service activities	90,91,92
Other services	1120,93,95,99
Unspecified	N/A

Notes: Taken from UNCTAD (2003), and ISIC codes are from United Nations (2008)

Education is unlikely to be associated with a purely linear manner with either FDI or population health. Hence a squared term was also included to capture the potential non-linear component.

Nationally aggregated years of education estimated by Barro & Lee (2013) were used to measure levels of education. This data is quinquennial, so linear interpolation was used to provide an annual value, as is common in the relevant literature (Desbordes & Azémar, 2009; Nunnekamp, 2002). Enrolment in secondary education was used as a sensitivity check, and was taken from the World Bank (World Bank,, 2015b).

Quality of institutions

Institutional quality and governance are acknowledged to be determinants of population health worldwide, and have also been linked to FDI, suggesting that they may have a confounding effect on the FDI-health association (Bénassy-Quéré *et al.*, 2007; Marmot *et al.*, 2008). An index of civil liberty compiled by Freedom House (2015) was used in all estimations, as this adequately proxies institutional and governmental quality whilst not explicitly including information on population health (see e.g. Desbordes & Azémar (2009) for a similar use of this measure). A range of alternative institutional, governance and globalization measures were explored. These were all found to explicitly contain information about FDI, or severely limit the size of the dataset due to missingness, and largely did not affect the results. Nevertheless, a set of models controlling for a measure of political rights, also from Freedom House, and the Heritage Foundation overall policy score are also included in the appendix (Freedom House, 2015) (See Table B.3) (Miller, 2015).

Urban population

Urban population size is likely related to population health in LMICs (Yusuf *et al.*, 2001b,a). There is also some evidence to suggest that the share of urban population size is a driver of FDI inflows, suggesting its confounding effect in the context of FDI and health (Hsiao & Shen, 2003). Consequently, World Bank, (2015b) data on urban population was included in all models.

3.3 Econometric Approach

3.3.1 Empirical strategy

The suggestions of Preston (1978) indicate that the income and health association is non-linear, time-variant and heterogeneous, and it was expected that this was also the case for FDI and health. Consequently, the study design for all the final estimations was a longitudinal panel analysis of country-level data which included country level covariates, time dummy variables, heteroscedacity robust standard errors and accounted for correlation between repeated observations for each country. Infant, child, and adult mortality rates were log-transformed, as they were right-skewed (Wooldridge, 2002).

Table 3.2: *Descriptive statistics and descriptions of variables, LMICs (1973-2013)*

Variables	**Variables definition**	**N**	**Mean**	**S.D.**	**Min**	**Max**
Outcome variables						
Life Expectancy	Life expectancy at birth in years, from World Bank (2015b)	2642	61.81	9.14	26.76	79.7
Infant Mortality	Infant mortality, per 10,000 live births, from World bank (2015b)	2642	57.76	33.86	6.9	165.9
under 5 Mortality	Under 5 mortality, per 10,000 under-5's, from World bank (2015b)	2642	86.14	61.5	8.1	336.5
Adult Mortality	Adult mortality at birth, per 10,000 Adults, from World bank (2015b)	2642	258.94	114.39	66.12	723.98
Covariate variables						
FDI inflows	Foreign Direct Investment inflows as a percentage of GDP, from UNCTAD (2014)	2642	2.58	4.6	-13.96	85.96
Secondary/ Total	Proportion of total FDI made up of investments into secondary industries, from UNCTAD (2008, 2004, 2003)	262	0.38	0.27	-0.1	1
Tertiary/ Total	Proportion of total FDI made up of investments into tertiary industries, from (UNCTAD, 2008, 2004, 2003)	262	0.44	0.24	0	1
Years of Schooling	National average of years spent in education, as estimated by (Barro and Lee, 2013)	2642	5.52	2.56	0.51	12.9
Years of Schooling, Squared	National average of years spent in education, as estimated by (Barro and Lee, 2013), squared	2642	37.01	30.99	0.26	166.54
Civil Liberties Index	Index of national levels of civil liberty, estimated by (Freedom House, 2015)	2642	4.13	1.41	1	7
GDPPC	Gross Domestic Product per capita of the FDI recipient LMIC, in year 2010 United States Dollars, from (World Bank, 2015b)	2642	180.26	19.66	< 0.01	13803.71
Urban Population	Urban population as a percentage of total population, from (World Bank, 2015b)	2642	41.39	18.47	3.37	86.37
Instrumental Variables						
Weighted sd(exchange rate)	5-year moving average of origin country standard deviation of local currency to US dollar exchange rate, weighted, from (International Monetary Fund, 2015; UNCTAD, 2015)	2642	3853831	81000000	0	2020000000
Weighted Capital Formation	Origin country gross capital formation as a percentage of origin country GDP, weighted. From (UNCTAD, 2015; World Bank, 2015b)	2642	22.83	5.57	6.51	48.17

Ordinary least squares (OLS) regression models were used as baseline estimations of the association between FDI and population health. These corrected for within-cluster correlation, and included time dummy variables. This is a useful benchmark, yet can be biased by time invariant differences between countries, and endogeneity. As a second benchmark, fixed-effects (FE) regression was used. This strategy adjusts for unobserved time-invariant heterogeneity between countries potentially correlated with both FDI and health, yet not for the endogeneity which would be a consequence of the bi-directional association between FDI and health (Wooldridge, 2002).

In Chapter 2, sections 2.3.2 and 2.4.2, evidence was identified indicating a two-way association between FDI and health (Also see Figure 3.1). This two-way association highlights the possibility that traditional OLS or FE regression analysis will be affected by endogeneity bias (See Wooldridge (2009) for a full discussion). Instrumental variable fixed effects (IVFE) estimation was used for the main analysis, as this approach is robust to endogeneity bias. This then allowed us to reliably test whether FDI is associated with health in LMICs (Section 3.3.2 below elaborates the IVFE strategy). These estimations were computed using the package xtivreg2 in Stata 13 (Schaffer, 2015; StataCorp, 2013), and are equivalent to estimates using two-stage least-squares estimation (Angrist & Pischke, 2008; Schaffer, 2015; StataCorp, 2013; Wooldridge, 2002). In two-stage least squares estimation, the first stage is an OLS fixed-effects regression of FDI as explained by a set of 'excluded' instruments, **Z**, ('Exogenous influences on FDI' in Figure 3.1), along with a set of 'included' instruments, **X**, and country-level fixed effects ('Factors influencing both FDI and population health' in Figure 3.1) (See Equation 3.1). The second stage is a similar OLS fixed-effects regression of health, explained by the fitted values of FDI from the first stage, $\widehat{FDI}$, **X**, and λ_i (Equation 3.2). **Z** are excluded from the second stage, resulting in them being referred to as excluded instruments. The results are robust to endogeneity only if the excluded instruments (**Z**) can adequately explain variations in FDI (in which case they are considered 'relevant'), whilst also lacking any ability to independently explain variations in health (in which case they are considered 'valid').

$$FDI_{it} = \boldsymbol{\gamma}\mathbf{Z} + \boldsymbol{\delta}\mathbf{X} + \lambda_i + \mathbf{t} + u_{it} \tag{3.1}$$

*Where FDI is FDI as a percentage of recipient country GDP, X is the set of control variables, λ is a country-level fixed effect, and **t** is a vector of dummy variables for time.*

$$ln(H)_{it} = \alpha\widehat{FDI}_{it} + \boldsymbol{\beta}\mathbf{X} + \lambda_i + \mathbf{t} + u_{it} \tag{3.2}$$

*Where H is a health outcome of interest (e.g. life, expectancy), X is the set of control variables, λ is a country-level fixed effect, and **t** is a vector of dummy variables for time.*

The ratios of secondary sector to total FDI, and tertiary to total, were used to explore industrial composition of FDI in relation to health in LMICs (Equation 3.3). The proportion of FDI composed of investments into primary industries was omitted. The interpretation of secondary FDI in this regression was consequently the impact on of increased secondary industrial concentration of FDI with respect to primary, whilst holding tertiary and total FDI inflows constant. In this case, valid and relevant instrumental strategy were not available, limiting the econometric approach to OLS and fixed-effects models.

Hausman specification tests indicated random effects estimation to be inconsistent for the sectoral analysis, leading to the use of FE. Results of this analysis are robust to time-invariant heterogeneity, yet vulnerable to bias caused by endogeneity.

$$H_{it} = \Psi + \theta_1 FDI_{it} + \theta_2 SEC_{it} + \theta_3 TER_{it} + \rho X + \lambda_i + \mathbf{t} + w_{it} \tag{3.3}$$

Where ψ is the intercept, SEC stands for secondary FDI as a proportion of total FDI, TER for tertiary FDI as a proportion of total FDI.

3.3.2 Instrumental Strategy

Determinants of FDI outflows from origin countries, weighted by the proportion of FDI received from the recipient's perspective were used as instrumentation (i.e. 'Exogenous influences on FDI' in Figure 3.1) for all IVFE models in Chapter 3. This approach was derived from research by Aggarwal *et al.* (2011), and Ahmed (2013), who investigate the consequences of cross-national income remittances to LMICs. Aggarwal *et al.* (2011) suggest that economic performance in origin countries can adequately estimate remittances (indicating 'relevance', as described in Section 3.3.1), with the argument that in times of economic prosperity, people have more disposable income to repatriate. At the same time, economic conditions in the origin countries are unlikely to directly affect financial development in recipient countries in a meaningful way (thereby indicating 'validity', as described in Section 3.3.1). In a similar vein, Ahmed (2013) uses oil prices to instrument remittances to Muslim, non-oil producing countries, finding these origin country determinants to be valid and relevant instruments.

Analogously to remittances, firms operating in a prosperous economic environment accumulate more profit and thus tend to have more capital to invest, leading to a larger outflow of FDI from the countries they are based in. Kyrkilis & Pantelidis (2003), Wang & Wong (2007) Cameron & Trivedi (2009); Cameron & Trivedi (2005), and Tolentino (2010) empirically support this, suggesting that factors like gross national income, interest rates, international trade levels, and exchange rate volatility affect outward flows of FDI.

Levels of gross fixed capital formation, and volatility of exchange rates in FDI origin (mostly high-income) countries as instruments for FDI flows into LMICs were used to identify the FDI and health association in LMICs. Capital formation is a general measure of economic performance, and for reasons discussed above, the final instrument was expected to be positively associated with FDI inflows to LMICs, yet independent from LMICs population health. The selected measure of exchange rate volatility was a five-year moving average of the standard deviation of local currency to USD exchange rate. As discussed by Wang & Wong (2007), exchange rate volatility in high income countries is likely to be a determinant of FDI outflows, and after controlling for GDP per capita, fluctuations in high income countries' exchange rates are unlikely to directly impact on population health, despite the fact many of them import pharmaceuticals. The set of origin countries included when calculating instruments was unrestricted, and as most FDI to LMICs originates from high income countries (see: UNCTAD (2015) bilateral FDI, statistics by country of origin), the capital formation and exchange rate volatility in the LMICs themselves were not a major influence on the final instruments. After controlling for GDP per capita in the destination country (i.e. the LMIC), the moving average of exchange rate volatility from the (mostly high income) origin countries was expected to be positively associated with FDI inflows to the destination country.

LMICs receive FDI inflows from multiple origins. Incorporating this information increases the explanatory power of the instruments, resulting in their increased relevance, whilst also maintaining a low level of explanatory power for health outcomes. The weighted versions of both instruments were computed as below, where i is FDI destination country, j is FDI origin country, W is proportion of FDI to i originating from j, EX is exchange rate volatility, and CF is capital formation (Equation 3.4)

$$
\begin{aligned}
Wg(EX_{it}) &= W_{ij}(EX_{jt}) \\
Wg(CF_{it}) &= W_{ij}(CF_{jt})
\end{aligned}
\tag{3.4}
$$

Statistical tests were used to examine how relevant and valid instruments were (as defined in Section 3.3.1). (Kleibergen & Paap, 2006) Lagrange Multiplier statistics (KP), with the null hypothesis that the instruments insufficiently explained variations in FDI (or lacked relevance), are reported as F-tests for the first-stage regressions (Equation 3.1). Hanson J-statistics, which in this context have the null hypothesis that the instruments are jointly unable to explain variations in health (and are therefore 'valid'), are reported for the second stage IV estimations (Equation 3.2) Hayashi (2000); Schaffer (2015). Nevertheless, it is possible that the economic performance of FDI origin countries could impact on destination country economic performance more directly due to globalization. Health in the recipient country could consequently be affected, since macroeconomic performance is related to population health, resulting in the instruments losing validity. To control for this, all models therefore included destination country GDP per capita as included instruments (see Section 3.3.1).

3.3.3 Testing for Endogeneity

Endogeneity tests are intuitive, yet only reliable when the excluded instruments used are both valid and relevant (Greene, 2003). Estimates from a method which is robust to endogeneity (in this case, IVFE) are compared to estimates from a method which is not (in this case, OLS). If the two sets of estimated coefficients vary significantly, this indicates endogeneity (Wooldridge, 2002). The Durbin-Hausman-Wu implementation of this approach is commonly used, yet is unreliable in the presence of heteroscedasticity. Therefore, a bootstrapped variant suggested by Cameron (2009), along with Cameron & Trivedi (2005); Cameron & Trivedi (2009) with 5000 iterations was used.

3.4 Results

3.4.1 OLS and FE Analysis

Table 3.3, Models 3.1 and 3.2 report results from simple OLS and FE models of the relation between FDI and life expectancy in LMICs. The OLS estimates do not imply that FDI is associated with life expectancy, and the FE estimations in Model 3.2 also indicates no correlation. However, Models 3.1 and 3.2 may both be affected by endogeneity bias, which can affect both the estimated coefficients and standard errors.

GDP per capita is reported to be positively related to life expectancy in Models 3.1 and 3.2. Years of schooling is associated positively with life expectancy in both models, as expected, and the negative coefficient on years of education squared indicates diminishing health returns to mean years of education amongst the population. Improvements in the institutional variable (lower scores) are not associated with health improvements in either model.

3.4.2 IV Analysis

In Table 3.3, Model 3.3 reports the instrumental variable fixed effects estimates of the association between life expectancy and FDI inflows in 85 LMICs 1974-2012. After controlling for the biasing effects of endogeneity, a 1% of GDP increase in FDI is found to be weakly statistically associated with 0.99-year increase in life expectancy. No net-effects of FDI on infant or under-five mortality rates were found in models 3.4 and 3.5, however (3.4). Finally, in Model 3.6 indicates that 1% of GDP increases in FDI are moderately associated with 0.79% reductions in adult mortality.

When substituting years of schooling for enrolment in secondary education, the model (Model B.1 in Appendix Table B.3) includes more LMICs (105 Versus 85), yet has fewer observations overall. The estimated results remain similar, suggesting that the use of years of education which have

Table 3.3: *Models of FDI and ln(Life Expectancy) in LMICs*

Model number	**(3.1)**		**(3.2)**		**(3.3)**	
Estimation method	**OLS**		**FE**		**IVFE**	
Model variables	**Coef.**	**pval**	**Coef.**	**pval**	**Coef.**	**pval**
FDI inflow (% GDP)	-0.096	(0.178)	0.033	(0.249)	0.993	(0.055)
Years of schooling	3.897	(<.001)	2.139	(0.046)	2.706	(0.022)
Years of schooling, squared	-0.175	(0.003)	-0.165	(0.002)	-0.193	(0.003)
Civil Liberties Index,lagged	-0.192	(0.625)	0.090	(0.660)	0.221	(0.332)
ln(GDPPC in 2010 USD), lagged	0.486	(0.018)	0.292	(0.012)	0.197	(0.007)
Urban population (% population)	0.120	(0.002)	0.018	(0.856)	0.026	(0.775)
Constant	41.579	(<.001)	48.752	(<.001)	-	-
Observations	2642		2642		2,642	
Countries included	-		84		85	
F-test	43.90		21.80		17.68	
F-test: 1st stage	-		-		6.82	
J-statistic	-		-		0.606	
(J-stat) Prob > P	-		-		0.436	

been linearly interpolated between each of the five-yearly observations presented by Barro & Lee (2013) did not noticeably affect the results. Similarly, when using an alternative measure of institutional quality from Freedom House (Model B.2, see Section 3.2.3) (Freedom House, 2015), the results were not affected. When using the Heritage Foundation freedom index overall policy score, FDI was not found to be statistically associated with health, yet this is likely because the institutional measure contains information on FDI and international trade (Holmes *et al.*, 2002).

Statistical testing suggests that the instruments were both able to explain variations in FDI, and unable to directly explain variations in health (i.e. the instruments were relevant and valid). In Model 3.3, the instruments were jointly significant (F = 6.82). The instruments and their lags were also individually significant. It was not possible to reject the J-statistic, suggesting that the instruments were jointly valid (P = .436). The results were not sensitive to including only weighted fixed capital as an instrument (Model B.3 in Table B.3). However, when using only weighted exchange rate volatility in Model B.4, FDI inflow was not statistically significant, suggesting it to be a weaker instrument in isolation.

The bootstrapped Hausman statistic of 11.96 (P < 001) comparing coefficients estimated by OLS and IV models of FDI and life expectancy indicated that Models 3.1 and 3.2 were systematically

Table 3.4: *Models of FDI and Mortality Rates in 85 LMICs*

Model number	**(3.4)**		**(3.5)**		**(3.6)**	
Estimation method	**Infant mortality, logged**		**under-5 mortality, logged**		**Adult mortality, logged**	
Model variables	**Coef.**	**pval**	**Coef.**	**pval**	**Coef.**	**pval**
FDI inflow (% GDP)	-0.02	(0.512)	-0.03	(0.366)	-0.079	(0.029)
Years of schooling	-0.116	(0.042)	-0.155	(0.025)	-0.10	(0.155)
Years of schooling, squared	0.00	(0.604)	0.00	(0.247)	0.01	(0.174)
Civil Liberties Index,lagged	-0.01	(0.304)	-0.02	(0.234)	-0.028	(0.080)
ln(GDPPC in 2010 USD), lagged	-0.023	(0.001)	-0.024	(0.002)	0.00	(0.757)
Urban population (% population)	0.00	(0.653)	0.00	(0.701)	0.00	(0.634)
Observations	2,642		2,642		2,642	
Countries included	85		85		85	
F-test	21.38		20.21		7.574	
F-test: 1st stage	6.01		6.01		6.01	
J-statistic	0.17		0.24		0.09	
(J-stat) Prob < P	0.68		0.62		0.77	

estimating different coefficients to Model 3.3. As the instruments were likely to be both valid and relevant in model 3 (See section 3.3.1), this implies that Models 3.1 and 3.2 were affected by endogeneity bias, and thus that endogeneity is indeed present when investigating FDI and health in LMICs.

Statistical tests indicate that the instrumentation used in Models 3.4-3.6 was relevant and valid. This can be seen by the 1st stage F-statistics and Hanson's J-statistic results in Table 3.3 (Wooldridge, 2002).

3.4.3 Sectoral FDI and Health

Table 3.5 reports OLS and FE models of total FDI, its industrial concentration, and life expectancy in 32 LMICs. Model 3.7 provides weak evidence that relative to primary sector FDI, and whilst holding secondary sector and total FDI constant, increased investment in the tertiary sector is net beneficial to life expectancy, yet this is not true of the secondary industries. In Model 3.8, which takes time invariant differences between LMICs into account, no association between tertiary FDI and health was found. Rather, increases in FDI industrial concentration in secondary industries are associated with reduced life expectancy. Finally, when investigating age-specific mortality (Not reported), an increased share of total FDI made up from secondary sector investments was found to be moderately statistically associated with small harmful impacts on infant and child mortality respectively, providing some support for the findings of Jorgenson, as discussed in Sections 2.3.2 and 2.4.2 (Jorgenson, 2009a,b).

However, when investigating aggregate FDI and health, strong evidence of endogeneity was

Table 3.5: *sectoral FDI inflows to LMICs and ln(Life expectancy) at birth*

Model Number	(3.7)		(3.8)	
Estimation Method	OLS		FE	
Variables	**Coef.**	**P-value**	**Coef.**	**P-value**
FDI inflows (% GDP)	0.022	(0.873)	0.010	(0.598)
Secondary/Total	4.544	(0.105)	-0.757	(0.099)
Tertiary/Total	4.896	(0.092)	-0.318	(0.470)
Years of Schooling	4.525	(0.061)	2.291	(0.026)
Years of Schooling, Squared	-0.285	(0.168)	-0.135	(0.049)
Civil Liberties Index	0.277	(0.716)	-0.243	(0.075)
ln(GDPPC)	1.775	(0.152)	-0.577	(0.000)
Urban Population	0.098	(0.147)	0.156	(0.002)
Constant	30.697	(0.009)	55.165	(0.000)
No. of Obervations	284		284	
No. of Countries	31		31	

Notes: P-values are heteroskedasticity robust; p<0.01, p<0.05, p<0.1

found. This implies that Models 3.7 and 3.8, which do not appropriately adjust for endogeneity in this case, are likely to be affected by the same biases which were found to affect Models 3.1 and 3.2. These results should therefore be interpreted cautiously. Finally, when removing data from China and repeating the sectoral analysis, the results were similar (total inflow coef. $< .001$, P = .46; Secondary FDI coef. = -1.19, P = .002).

3.5 Discussion

3.5.1 Prinicpal Findings

Ordinary least-squares (OLS) and fixed-effects (FE) models of the association between aggregate FDI and life expectancy (Models 3.1 and 3.2 in Table 3.3) do not support the idea that FDI has a net-impact on health in LMICs. However, strong evidence of endogeneity was found when using bootstrapped Hausman tests, which indicated that these methods were susceptible to producing both biased coefficients and standard errors, leading to unreliable results and inference. The instrumental variable fixed-effects (IVFE) model of life expectancy (Model 3.3), which controls for the influence which endogeneity has on the estimated coefficients and standard errors, links a 1% of GDP increase in FDI to a 0.993-year increase in life expectancy. Over the study period, the mean FDI inflow to LMICs scaled by GDP has increased from 0.83% to 5.01% (UNCTAD, 2014; World Bank,, 2015b). This implies that FDI in LMICs may be associated with an up to 4.15-year increase in life expectancy between 1974-2012. This is a moderate effect over a 38 year period in which the majority of LMICs underwent many other significant developmental changes, undoubtedly overshadowing this effect. Nevertheless, this chapter indicates that increased FDI to LMICs, which itself is a result of increased freedom of trade and globalization worldwide, has had a net-positive impact to population health over the 38 years considered.

This chapter investigated the differential impacts of FDI on age-specific mortality, after adjusting for endogeneity as in the main analysis. Model 3.6 provides moderate evidence that a 1% of GDP increase in FDI is associated with a 0.08% reduction in adult mortality, while no evidence was found of any net-effect of FDI on either child or infant mortality rates. Consequently, the overall positive effect of FDI on life expectancy appears to be driven by improvements in adult health, as opposed to child or infant health, in LMICs. This is plausible, given that increases in wages for skilled labour and improvements in working conditions owing to FDI are arguably more relevant to adults than children (Feenstra & Hanson, 1997; Moran, 1998, 2004). Further, Jorgenson shows that FDI related pollution is associated with elevated child and infant mortality, yet not adult mortality (Jorgenson, 2009a,b). One interpretation is then that the harmful effects of FDI in LMICs may be stronger in child and infant populations, offsetting the otherwise beneficial effects. Going forward, researchers should be mindful of this potential differential impact, and at least test the sensitivity of their findings to use of infant, child, and adult health outcomes where possible.

The ratio of tertiary FDI to total FDI was found to be beneficially associated with life expectancy in OLS models, yet not associated in fixed-effects models, ceteris paribus. On the other hand, the ratio of secondary FDI to total FDI was not found to be associated in OLS models, yet harmfully associated when using a fixed-effects approach. As appropriate instrumentation was not available, these models did not control for endogeneity, however, and due to the similarity of econometric context, these findings are therefore likely to be confounded by similar levels of endogeneity bias to Models 3.1 and 3.2 (Table 3.3). This bias could be affecting both the model coefficients and standard errors, and hence those results should consequently be treated as exploratory and interpreted with care. Nevertheless, whilst FDI can and does on aggregate improve conditions in LMICs, the extent to which this is happening is related to the kinds of industries which are entering markets. This indicates that both the amount of FDI and the type of FDI could be important influences on its overall health impacts. Yet, the extent to which this can be reliably explored in LMICs is currently limited by the availability and quality of industrially disaggregated FDI data.

3.5.2 Recommendations for Future Research

More research investigating the association between FDI in specific industries and overall health is needed. The work hitherto undertaken focused on tobacco, calorie consumption, and pollution (Gilmore & McKee, 2005; Hawkes, 2005; Jorgenson, 2009a,b). These works identify the channels connecting FDI and the determinants of health outcomes in LMICs. However, the impact of FDI on population health in different industries remains unclear. Work attempting to identify the industries which might be associated with the most health benefit would be valuable in shaping future trade agreements and FDI promotions internationally. Further, future data collection and research at the intersection of international macroeconomics and population health in LMICs should focus on important sub-populations, such as those based on demographics and socio-economics (for instance, adult and infant mortality in urban and rural settings). This will allow researchers to more precisely explore how macroeconomics and globalization are affecting health in LMICs.

From a methodological perspective, it is recommended that when investigating bilateral international macroeconomic variables like trade and FDI, there is a need to take endogeneity into account, to avoid biased results and unreliable inference. The IV approach used here may be one promising avenue, in which case indicators of the economic environment in countries which trade heavily with the country of interest could be suitable candidates for instrumental variables. At the same time, other quasi-experimental approaches may also be worth exploring in this context (Craig *et al.*, 2012).

3.5.3 Strengths and Lmitations

The reported estimations draw from many LMICs, and are therefore reasonably generalizable to all LMICs.

Most notably perhaps, a novel instrumental variable strategy was employed for the first time in the cross-country health impacts of FDI literature. The instruments used appear to be both valid and relevant in this case. Weighted origin country gross capital formation is a strong predictor of FDI, and is exogenous if IVFE models also include GDP per capita to account for economic integration of the origin and destination countries. For future cross-country studies of macroeconomic factors and health investigating bilateral FDI statistics, IV strategies taking the country of origin into account are worthy of consideration.

Data on FDI to LMICs which is disaggregated by sector or industry is very limited, and Theodore H Moran has argued that the primary, secondary, and tertiary categories used by UNCTAD may not be optimal for identifying developmental and health impacts of FDI (Moran, 2005, 2011, UNCTAD, 2003, 2004, 2008). Use of sectoral rather than industrial level FDI inflows limits the possibility of parsing out the specific industries, or combination of industries which as a group translate to country-level outcomes of interest, including population health. Work to improve the availability and quality of cross-national FDI data by sector or industry in LMICs would facilitate research investigating deeper into the association between FDI and population health and the determinants and consequences of FDI in specific industries.

Some previous empirical study has indicated that the association between FDI and population health is likely to be long term as well as short term (Alam et al., 2015). Although Feenstra et al. suggest short term increases in pay for skilled workers result from FDI to LMICs, the health implications of this, and more incremental changes identified by Moran suggest a gradual cumulative effect (Feenstra and Hanson, 1997; Moran, 2011). The study design in this chapter used lagged variables and took correlation over time within individual countries into account, yet the findings were consequently still unlikely to capture the potential longer-term health impacts of FDI to LMICs.

Yang & Martinez (2006) suggest that currency depreciation affects a migrant's level of remittance to their home country, which may have its own separate effect on population health. This weakens the case for the validity of exchange rate volatility as an instrument for FDI. However, both instruments used were individually significant in the first stage estimation, and exclusion restrictions testing indicated their joint exogeneity. For this investigation, therefore, both instruments were considered appropriate.

Levels of labour market informality may confound the association between FDI and health, particularly if firms engaging in FDI to LMICs take advantage of it. Unfortunately, no widely available data on this exists for LMICs, and this aspect of the association must therefore be left to future research efforts.

Some research has identified flaws in disaggregating FDI by primary, secondary and tertiary sectors, suggesting that using sectoral classifications based on the nature of the work involved (from the perspective of workers) may better isolate developmental, and potentially health, effects associated with FDI (Moran, 2011). Future attempts to measure FDI to LMICs, and investigations into health effects should seek to investigate more closely, and with hopefully more comprehensive data, the ways in which different types of FDI matter for health.

There is some evidence to suggest that population health may drive income in LMICs, as it does FDI (Borensztein *et al.*, 1998; Hansen & Rand, 2006; Li & Liu, 2005). If this is the case, inclusion of GDP per capita in Models 3.1-3.8 (Table 3.3 and Table 3.4) may have led to a small amount of endogeneity bias, through the relationship between income and population health. However, controlling for income was crucial to the validity of the instruments. Finally, trade agreements and bilateral investment treaties may have confounded the analysis. These agreements may instigate the changes that lead to improvements in population health, and not FDI (Busse *et al.*, 2010). However, the fixed effects estimator, inclusion of time-dummies and calculation of cluster-robust standard errors were likely to largely adjust for this.

3.6 Conclusions

The conclusion of this chapter is that when adjusting for endogeneity, aggregate FDI to LMICs is beneficially related to life expectancy and adult mortality, yet is not associated with infant or child mortality rates. Some evidence was identified, suggesting that secondary sector FDI is harmful to overall health in LMICs when taking time-invariant country-level heterogeneity into account, but this conclusion remains tentative due to data constraints prohibiting a more robust approach. Taken literally, at least based on mortality data that used in Chapter 3, FDI into LMICs appears to chiefly affect the adult population, which may warrant some adult-oriented focus of further research on the association between FDI and health in LMICs.

The research question for this chapter aimed to address three of the four key messages raised in Section 2.4.2. These included the likely importance of FDI to population health, the importance of which countries are included in analyses, and the likelihood of a two-way association between FDI and health. The primary analysis was a cross-country instrumental variable regression analysis of the association between FDI and overall life expectancy within low and middle income countries (LMICs). The results provided moderate evidence to suggest that after adjusting for endogeneity, FDI is associated with small net-improvements in overall life expectancy within LMICs. When investigating FDI and age specific mortality, no evidence of an association between FDI and infant or child mortality was found. As mentioned in Section 1.1.4, FDI levels are changing alongside a range of other factors related to economic globalisation (and globalisation in the wider sense). Consequently, the FDI and population health association in LMICs could be mediated by some of these changes. One of these, as pointed out by Jorgenson (2009a) and Jorgenson (2009b) is likely to be water pollution, yet that does not imply that this is the only factor at play. Increasing incomes resulting from FDI (as suggested by Feenstra & Hanson (1997)) can lead to improvements in the ability to provide adequate nutrition or healthcare to children which may have positive effects. Yet by the same token, the quality of food could be decreasing at the same time (as suggested by Hawkes (2005)), and pollution could be rising. These opposing factors could lead to no association being found, or could be mediating said association.

The analysis did, in spite of these possible mediating factors, provide evidence of a small beneficial association between FDI and overall adult mortality rates in LMICs, on the aggregate level. To the extent that mortality serves as a good proxy for population health, this was taken to imply that currently available evidence indicates the net benefit of FDI to health within LMICs to be largely within adult populations. At this point, it would likely be fruitless to investigate the association between FDI and population health for children. This is because thus far no evidence has been identified to suggest an association. On the other hand, the association with adult health appears to be robust enough to still be identifiable, in spite of possible mediating factors. Therefore, the focus of this thesis now shifts to the health impacts of FDI on adult populations within LMICs.

Chapter 3 also included exploration of whether the relationship between FDI and health on the aggregate level might be confounded by characteristics of FDI other than simply its volume. Due to data constraints, the investigation of FDI industrial composition was limited to whole sectors, restricted to a small subset of LMICs, and was unable to account for the possibility of endogeneity. Nevertheless, when controlling for country-level time-invariant heterogeneity, some preliminary evidence to suggest that the proportion of FDI in secondary industries may lead to net-harm to population life expectancy was found. The investigation of FDI and its characteristics with respect to health in LMICs therefore includes consideration of FDI characteristics other than volume alone.

3 serves as a basis to build on with respect to investigations into FDI and health. It provides evidence of FDI health implications in LMICs. Yet, it also raises questions about how types and amounts of FDI affect the health of different people within a LMIC. Due to the cross-country aggregated nature of 3, and the use of an overall health outcome like mortality, the analysis was inevitably susceptible to aggregation bias, or 'ecological fallacy', and insensitive to some nuances of this association — for instance the effect which FDI may have on nutritional health or health behaviours. Consequently, all subsequent investigations into the association between FDI and adult health focus on the individual level association, and explore different component parts of population health, including nutritional health outcomes and health behaviours.

In Chapter 4, the focus shifts to a case study of China to investigate the association between FDI and nutritional health. Focusing on an individual country eliminates many problems typically associated with cross-country studies, like significant heterogeneity between countries which is unobservable and time-variant, and fundamental differences in underlying drivers of health. It also allows utilisation of valuable individual-level datasets, and permits the exploration of specific aspects of health or health-determining behaviours (Cameron & Trivedi, 2005; Jones, 2000, 2007).

CHAPTER 4

Regional Foreign Direct Investment and Individual Health in China: A Spatial Econometric Approach

4.1 Introduction

Foreign direct investment (FDI) has been linked with the availability, marketing, and reduced price of highly processed foods in low and middle income countries (LMICs) (Hawkes, 2005; Stuckler *et al.*, 2012). If this is indeed the case, then FDI has potentially played a role in changing health behaviours over time in these countries, and consequently has impacted nutritional health outcomes. There has been some previous exploration of this link using quantitative methods. Yet, as discussed in Chapter 2, it has been the impact of economic globalisation as a whole, rather than FDI specifically, that has been the focus of the existing, and rather scarce, quantitative research in this area (Vogli *et al.*, 2014). Vogli *et al.* (2014), in a panel data regression analysis found a positive association between KOF1 (See Section 2.3.1) and BMI, suggesting that when adjusting for confounding factors population BMI is higher in countries which are more economically globalised. By extension, this suggests that FDI (which forms a major component of KOF1) may play a role.

There are two studies to date which focus on FDI, rather than economic globalisation in the wider sense, and its implications for nutritional health. Hawkes explored FDI and nutritional health using data on FDI to LMICs within the food sector, and levels of food-related sales (Hawkes, 2005). Hawkes identified that parallel to global increases in FDI during the 1980s and 90s, there were similar increases in the proportion of investments associated with host market demand for highly processed foods in LMICs. When taken at face value, this may be inferred to suggest that food FDI is worsening diets in LMICs. Hawkes suggested that direct investments facilitate the avoidance of various barriers to international trade like transit costs, import or export tariffs, and restrictive market access conditions, leading to falling prices relative to the goods that domestic firms supply. These changes in price relative to the alternatives that consumers are faced with, alongside increased levels of localised (or globalised) marketing or brand recognition, could be driving demand for these goods, leading to a knock-on effect on population health. More recently, Stuckler *et al.* (2012) supported Hawkes' findings. The authors suggested that demand for what they term 'unhealthy commodities' is likely to increase in association with direct investments due to falling prices, increased market competition, and rising incomes. Their work also included some quantitative analysis, which suggested a link between FDI and 'population exposure' to unhealthy commodities, as measured by quantity (in kilograms) available per capita.

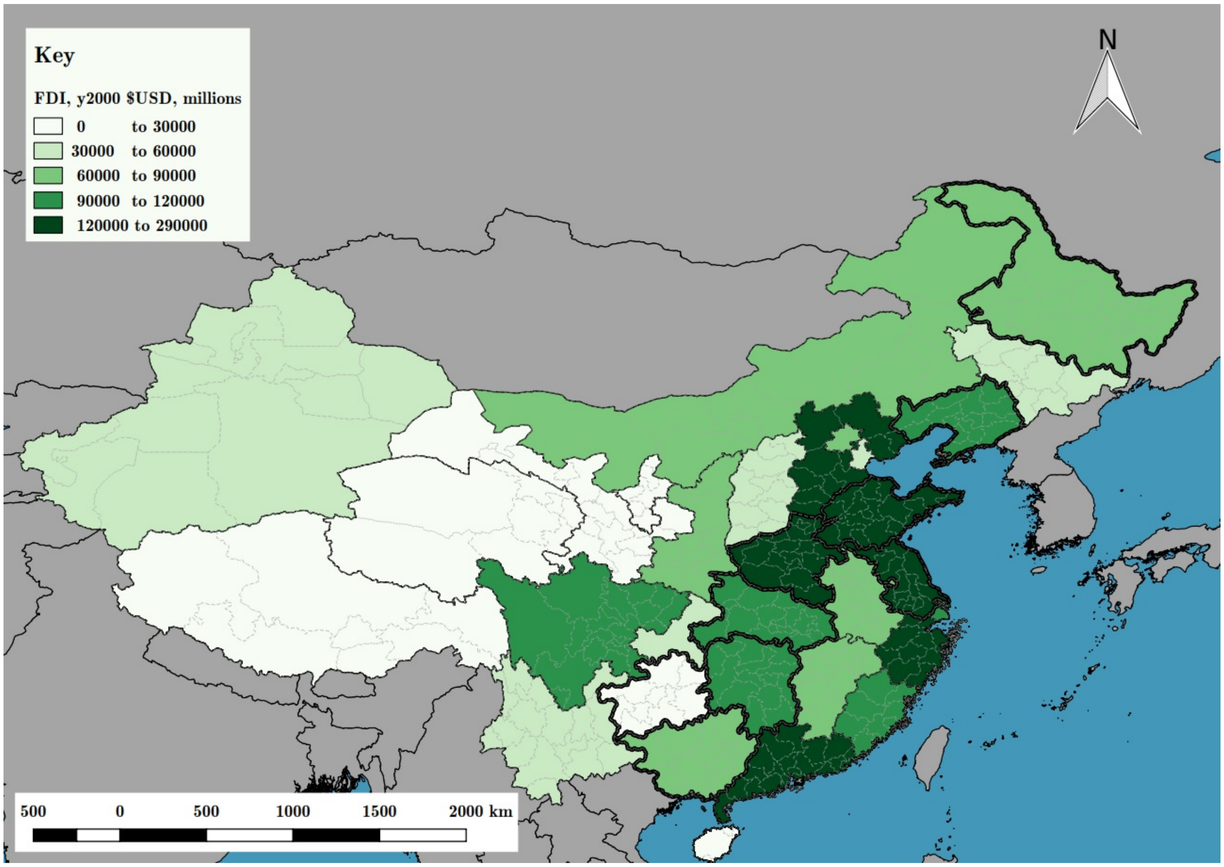
Stuckler *et al.* (2012) identified a country-level association between FDI and exposure to unhealthy commodities in LMICs, and Hawkes also found a positive correlation between food industry FDI and food sales. Taken together, this evidence does suggest a possibly causal association between the amount of FDI in an LMIC and subsequent changes in nutritional health. Yet, both studies stop short of directly, statistically establishing such a link (Blouin *et al.*, 2009; Hawkes *et al.*, 2009; Subramanian *et al.*, 2002). Assessing the existence, and magnitude of any association between levels of FDI and nutritional health outcomes would, however, be important when seeking to understand how globalisation affects health worldwide, as FDI is increasingly a core means by which multinational firms access new markets. Therefore, this Chapter aims to fill this gap in the evidence by conducting an econometric analysis of the impact of FDI on a key nutritional health outcome, BMI, in China. Due to the increasing availability of economic data from LMICs, it is now possible to investigate the FDI and nutritional health association using econometric methods.

In the late 1980s, FDI flows to China were very small. However, following the government's decision to permit FDI inflows to the country in 1992, FDI to China grew rapidly, and it is has become the recipient of the largest FDI flows of any country (Blanc-Brude *et al.*, 2014; Coughlin & Segev, 2000). This rapid increase provides an opportunity to conduct a case study of the impacts which FDI has had on the nutritional health of the Chinese population during that time.

The aims of this chapter are 1) to establish whether greater FDI exposure is associated with higher BMI amongst Chinese adults with a focus on the individual level association and 2) to explore the differential impacts of FDI exposure on those adults at different levels of BMI.

4.2 Data

From the beginning of the 1990s, FDI to China has been mostly concentrated around the eastern coast, with more inland regions receiving relatively limited interest from foreign investors (Coughlin & Segev, 2000). Some evidence has linked these regional discrepancies in FDI to differences in levels of urbanisation rates and economic prosperity (Zhang, 2002). Urbanisation



NOTES: Data on administrative boundaries is taken from `http://www.gadm.org/`*; Regions outlined in bold are those included in the CHNS for more than one wave*

Figure 4.1: *Regional FDI in China, 1993-2011*

and economic development could act as confounders in the analysis, due to regional or even community level heterogeneity. Furthermore, there is considerable evidence to suggest that FDI to one region or even whole countries has an impact on contiguous regions or countries (Blanc-Brude *et al.*, 2014; Coughlin & Segev, 2000; Sharma *et al.*, 2014). As the regional distribution of FDI is possibly an important factor in the association between FDI and nutritional health outcomes in this case, regionally disaggregated economic data is used for the analysis presented in this chapter (discussed further in Sections 4.2.2 and 4.3).

Flows of FDI to China have been increasing since the 1990s. To take this into consideration, it is most beneficial to utilise both longitudinal economic statistics, and also longitudinal nutritional health data covering the same period, at as many points in time as possible, and across as many geographical regions as possible. A widely-used relevant survey is the China Health and Nutrition Survey (CHNS), which began in 1989 and included individual level data on over 30,000 individuals in total over the period 1989-2011. The CHNS collected data from 8 of China's 31 (30 until 1997) regions in 1989, 1991 and 1994; 9 regions in 1997 2000, 2004, 2006 and 2009; and 12 regions in 2011 (Zhang *et al.*, 2014). The questions in the CHNS included — amongst others — community, household and individual demographic, socio-economic and physical characteristics.

Figure 4.1 is a map of mean FDI inflows to Chinese regions from 2000 to 2011, in millions of constant year 2000 US Dollars. Administrative borders of regions included in the CHNS in more than one wave are outlined with a thick black line. Figure 4.1 shows that there has been a considerable amount of geographic clustering of FDI in China, in line with the suggestions of Coughlin & Segev (2000), and Sharma *et al.* (2014). Further, there are CHNS regions included at multiple waves which have both low and high volumes of FDI inflow during the 1989-2011 period. This provides opportunity to use data from China as a case study to investigate the association between FDI and nutritional health in LMICs.

4.2.1 Outcome Variable

Table 4.1 lists the data sources and descriptive characteristics of all the variables that were used in the analysis. Individual level BMI measurements, collected from the CHNS, were used as a proxy measure for nutritional health in the Chinese adult population. The complete-case individual-level sample included 56,319 observations from 15,825 different individuals within 4,990 different households, across nine Chinese regions, spanning the years 1993 to 2011. The household level sample included 25,445 observations across the 7 CHNS rounds, meaning 72.85% of the 4,990 households responded on average. The regional level sample included 61 observations across the 7 CHNS rounds (9 regions for 7 CHNS rounds, with two missing data points). Inspection of the individual sample led to the identification of ten instances of extreme BMI values (less than 10 or over 100). These observations were omitted due to their higher potential for measurement error (for instance, use of inches instead of cm for height or lbs instead of kg for weight). The numbers of observations in Table 4.1 reflect the number of distinct observations. The number of distinct measurements of age is 56,319, but as age is a linear function of time, the number of unique age observations for age at the first CHNS round is 15,825.

4.2.2 Predictor Variable

Data on foreign investment to each of 31 Chinese mainland regions was taken from the National Bureau of statistics of China (2014). The earliest available data were for 1992, which covered most of the available CHNS data (National Bureau of statistics of China, 2014; Zhang *et al.*, 2014).

There is a considerable body of evidence confirming the intuitively obvious: that the economic effects of FDI are not entirely geographically arrested by administrative boundaries between regions, and that the economic benefits of FDI in one region may consequently extend to those around it (Blonigen *et al.*, 2007; Coughlin & Segev, 2000; Sharma *et al.*, 2014). Simply using regional inflows of FDI to capture actual exposure to FDI within any one region would therefore represent a measurement error. In an econometric context, this may lead to biased estimations, with the degree and direction of bias being difficult to identify or adjust for.

Table 4.1: *Descriptive statistics used in the analysis for Chapter 4*

Variables	Description and sources	Obs.	Mean (% sample)	S.D.	Min	Max
Individual Health Outcomes						
BMI, (kg/m^2)[c]	Body mass index in $\frac{kg}{m^2}$, from Zhang *et al.* (2014)	56,319	22.88	3.43	12.12	67.59
Regional covariates						
Regional FDI Exposure[a]	The sum of regional FDI and spatially lagged FDI to other regions of China in millions of constant year 2000 US Dollars (See Equation 4.2), from NBSC* 2014	61	195789	126002	40246	510999
Lagged GRP, (year 2000 USD)[a]	One period lagged Gross Regional Product, in millions of year 2000 United States Dollars, from NBSC 2014	61	110169	108846	8886	508396
Regional population, 10,000s of people[a]	Reported regional population in 10,000s of people, from NBSC 2014	61	6074	2068	3409	9717
Regional education, (% Regional sample)[a]	Percentage of the regional population with a maximum education level of vocational degree or lower, from Zhang *et al.* (2014)	61	88.86	2.74	77.55	93.23
Household covariates						
Household size, (people)[b]	The number of individuals living in the household of the individual, from Zhang *et al.* (2014)	11,116	3.9	1.59	1	13
Asset index[b]	An index of personal wealth incorporating information on household level assets, broken into dummy variables based on quintile Zhang *et al.* (2014)	4,990	-0.02	0.91	-2.31	8.04
Individual covariates						
Age, (Years)[c]	Age in years, from Zhang *et al.* (2014)	56,319	46.87	15.74	18	100
Sex, (1 = Male)[c]	Equal to one if individual is male, zero otherwise, from Zhang *et al.* (2014)	15,825	0.4752	-	-	-
Nationality, (1 = Not Han)[c]	Whether the individual is of Han descent or not. Equal to one if the individual is not Han, from Zhang *et al.* (2014)	15,825	0.1293	-	-	-
Urban/rural, (1 = Urban)[c]	Whether the individual lives in an urban or rural environment. Equal to one if urban, from Zhang *et al.* (2014)	15,825	0.2844	-	-	-

**NBSC is the National Bureau of Statistics of China*

a: observations are on the regional level; b: observations are on the household level; c: observations are on the individual level

Observations are one for each CHNS published, or the year before each CHNS in the case of lagged values, see Section 4.2

To account for inter-regional FDI effects, an FDI exposure measure utilising data on regional FDI and geographical proximity was computed in a similar fashion to previous work by Sharma *et al.* (2014). Data on regional FDI was compiled into an ($\mathbf{R}$ x $\mathbf{T}$) matrix of inflows to Chinese regions over time, $\mathbf{F}$ (where $\mathbf{R}$ is the total number of regions, and $\mathbf{T}$ is the total number of time points). Secondly, weightings based on straight line distance between regional capital cities in kilometres (w_{rs}) were compiled into an (**R** x **R**) matrix, **W**. Distances to inform **W** were manually calculated using Gmaps Pedometer (Google Inc., 2015, 2017). In a similar vein to Sharma *et al.* (2014), distances in km were converted into weightings using the shortest distance between two regional capitals in China as the numerator, $min[D_{rs}]$ as shown in Equation 4.1 $min[D_{rs}]$ was found to be the 114km between Beijing and Tianjin, and this was used as the numerator in each element of **W** (See Equation 4.2). Thus, the resulting measure of FDI took into account the FDI entering surrounding regions, and also how far away those regions were. Henceforth, this is referred to as spatially weighted FDI, or FDI exposure.

$$w_{rs} = \frac{min[D_{rs}]}{D_{rs}} \tag{4.1}$$

$$\mathbf{W} = \begin{bmatrix} 1 & \dots & w_{Rs} \\ \vdots & \ddots & \vdots \\ w_{sR} & \dots & 1 \end{bmatrix} \tag{4.2}$$

$$\mathbf{F} = \begin{bmatrix} FDI_{1,1993} & \dots & FDI_{1,2011} \\ \vdots & \ddots & \vdots \\ FDI_{9,1993} & \dots & FDI_{9,2011} \end{bmatrix} \tag{4.3}$$

$$\mathbf{W} \times \mathbf{F} = \mathbf{WF} \tag{4.4}$$

4.2.3 Regional Covariates

Gross Regional Product

The association between regional exposure to FDI and BMI in China is likely to be partially confounded by regional income levels, and this was controlled for via inclusion of gross regional product (GRP), in constant year 2000 USD, in all models. Regions with a higher level of GRP per capita were expected to have more disposable income, and consequently consume more calories, leading to higher BMI. However, there is likely to be a two-way relationship between GRP, or GRP growth, and FDI, leading to some endogeneity in estimations including GRP. In order to adjust for this as much as possible, one-year lags of GRP were used for all estimations.

Education

Human capital is a positive determinant of FDI inflows to LMICs, and therefore the regional level of employment was an important factor to control for in the estimation (Noorbakhsh *et al.*, 2001). The regional level of education was proxied using the proportion of the regional population with a vocational degree or below. This variable was expected to be positively associated with BMI, as those with less education were expected to have poorer nutritional health, holding other factors constant.

4.2.4 Household Covariates

Household covariates were included to reduce residual variation in the outcome variable, thus increasing the precision of the parameter estimations in the estimated models.

Household Size

Doak *et al.* (2002), when investigating CHNS data from 1993, found that the variability of household members' BMI was positively associated with the size of the household they were a part of. Household size was therefore included in all estimations.

Household wealth Survey responses from the CHNS on household assets were used to measure wealth at the household level, following guidance from the World Bank (Filmer & Pritchett, 2001). In order to compile simple asset scores, recommendations from the Word Bank Institute's "Analysing Health Equity Using Household Survey Data" were applied to the CHNS household survey responses for each of the waves included in this chapter (O'Donnell & Doorslaer, 2008). The asset scores were calculated based on information about household and personal electronics, vehicular ownership and home ownership. Appendix Table C.1 reports descriptive statistics of each variable used to compile asset scores from the CHNS data.

4.2.5 Individual Covariates

Individual covariates were included to further improve the precision of the estimations. The individual level control variables included age and squared age, sex, race (Han or not Han), and urban/rural status.

BMI changes with age, yet this is unlikely to be at a constant rate over time due to age related factors including muscle wastage. To adjust for changing BMI at different ages, age and age squared were both included in all estimations. Males and females are likely to have different average BMI levels. Consequently, a dummy for sex was included in all estimations. Previous empirical studies of obesity in China have indicated notable differences between rural and urban populations, and therefore a simple dummy variable for urban or rural area status from the CHNS was used (JI Cheng Ye *et al.*, 2013; Ji & Cheng, 2008; Ye & Cheng, 2009). Individuals were free to change status from rural to urban in different waves of the CHNS.

4.3 Econometric Approach

4.3.1 Empirical Strategy

The estimation approach was panel-data regression analysis. Two separate fixed-effects (FE) models of the association between FDI and BMI in Chinese adults were estimated (See Equation 4.5). The first simply included levels of regional FDI inflows as a measure of exposure to FDI to evaluate whether regions which receive more FDI have higher individual BMI. The second model used **WF** as a measure of exposure to FDI (i.e. spatially weighted FDI), to take inter-regional diffusion of FDI effects into account (See Section 4.2.2). Evaluation of the significance, sign and magnitude of the respective FDI coefficients in these two models then provided some insight into the importance of spatial diffusion of FDI impacts on the nutritional health of the Chinese population. If, for instance, **WF** is a strong predictor of BMI whilst regional FDI is not, this would suggest that FDI in one region affects BMI in another. Consequently, clusters of contiguous smaller regions which receive large amounts of FDI are likely to encounter larger increases in population BMI.

$$BMI_{it} = \mathbf{Xb} + \lambda_c + \epsilon_{it} \tag{4.5}$$

Where λ is a fixed effect, on the community (c) level, i is the individual, t is the time point $\boldsymbol{X}$ is the matrix of observations, $\boldsymbol{b}$ is the vector of regression coefficients, see Table 4.1

Due to the likelihood that health behaviours over time — and consequently BMI over time — are not independent, standard errors were calculated using the sandwich method on the community level (Angrist & Pischke, 2008). The community level was chosen, as this is likely to take into account differences in local cultures and health impacting behaviours.

Another possible caveat to investigation of the link between regional FDI and individual BMI in China is evidence suggesting that macroeconomic determinants of BMI may have differential effects on those at different levels of BMI (Gordon-Larsen *et al.*, 2014; Shankar, 2010). To investigate whether this is the case with FDI, quantile regression analysis was used (Cameron, 2009; Cameron & Trivedi, 2009; Parente & Santos Silva, 2016). In contrast to standard regression, which is concerned with estimating the marginal effect of a covariate on the conditional mean of a dependent variable, quantile estimation is concerned with estimating the marginal effect on a conditional quantile. For instance, quantile estimation of the 50^{th} BMI percentile in this case would be a regression to estimate the median of BMI amongst Chinese adults, conditional on FDI and the control variables (Cameron, 2009; Cameron & Trivedi, 2009). A significant coefficient in this regression estimate is therefore interpreted as the effect of the variable (e.g. FDI) on the conditional median BMI in the Chinese population.

To achieve this, two approaches were used. Firstly, the user-made Stata command, *qreg2*, which utilises a similar estimation algorithm to that of the in-built Stata command *qreg*, but with the advantages of being able to compute cluster-robust standard errors via a sandwich estimator (as with the baseline models discussed above), and the inclusion of a test for intra-cluster correlation (Parente & Santos Silva, 2016). This was used to estimate the association between **WF** and the 25^{th}, 50^{th} (median) and 75^{th} percentiles of BMI amongst the Chinese adult population. Following this, F-tests were used to test whether the **WF** coefficient estimates varied significantly by conditional quartile being estimated. This consisted of a total of four F-tests; one to compare the 25th quantile estimate results to the 50th; one for the 50th and 75th; one for the 25th and 75th; and finally one F-test for equality of all three sets of estimates. The null hypothesis of these tests was no difference between coefficients, and consequently that the effect of **WF** on BMI has been indistinguishably similar for Chinese adults at all levels of BMI. Consequently, this suggests that the conditional mean estimate (i.e. the OLS estimate) is sufficient to capture the association between **WF** and BMI in the Chinese adult population. Finally, to check that *qreg2* estimations were consistent with those from the in-built stata estimators, a bootstrapped variant of the median quantile regression was used, using the stata command *bsqreg*, with 5000 iterations (Koenker, 2005). Following this, bootstrapped quantile regression estimates with 2000 iterations at every percentile between the 5th and 95th, using simultaneous quantile regressions, were calculated. The resulting estimator was highly computationally demanding (Cameron & Trivedi, 2009). These estimations were compiled into a graphical format using ggplot (Wickham, 2009), within the R statistical software (R Core Team, 2017), to provide visual representation of FDI effects across the distribution of BMI in the Chinese adult population. The process was repeated using regional FDI as the measure of FDI exposure. This was done to distinguish whether the estimated association between FDI and BMI was estimated to be different at all levels of BMI when using regional FDI and **WF** as FDI measures.

4.4 Results

4.4.1 Primary Analysis

Estimation sample sizes by region and wave are available in Appendix Table C.2, along with numbers of communities, households and individuals used in the estimation, by region in Appendix Table C.3. Models 4.1 and 4.2 are reported in Table 4.2. Model 4.1 is an OLS estimation of the relationship between regional FDI inflows and BMI in nine mainland regions of China, 1993-2011. This provides no evidence of an association between regional FDI inflows and BMI after adjusting for confounding factors, time-invariant unobserved heterogeneity, time trends and when calculating cluster-robust standard errors. Model 4.2 is a similar model, substituting regional FDI for **WF** (See Equations 4.1 and 4.2). Conversely to Model 4.1, this provides strong evidence that during the 1993-2011 period, and after adjusting for confounding factors, a 10% increase in **WF** was associated at the 99.9% level of confidence with a 0.132 kg/m^2 increase in mean BMI amongst the Chinese adult population.

The sign and significance of the estimated coefficients for control variables were predominantly as expected. The proportion of the CHNS regional sample which had the highest level of education of vocational or below was found to be positively associated with BMI in model 4.1, yet was not significantly associated in Model 4.2. Being in the 3rd asset quintile is associated with lower BMI than being in the first (controlling for other factors), yet those in the 4th or 5th quintile (the highest levels of material wealth) were found to have significantly higher BMI than those in the 1st, when controlling for other factors. Older people were estimated to have higher BMI, but at a diminishing rate. Being male was associated with lower BMI, not being of Han descent with lower BMI and living in urban areas with 0.533 kg/m^2 higher BMI than rural areas.

4.4.2 Quantile Regressions

The simultaneous quantile regression results for the 25th, 50th and 75th percentiles of BMI, estimated with cluster-robust standard errors, are reported in Table 4.3 (Models 4.3-4.5). All three of these models provided strong evidence of an association between **WF** and BMI in Chinese adults, with some minor variation in the estimated coefficient on FDI exposure. The F-statistic for equality of the 25th and 50th quantile coefficient estimates was 0.62, which cannot be rejected at any confidence level. Hence, no evidence that the BMI of those at the median level of BMI within the Chinese adult population were affected differently by **WF** than those at the

Table 4.2: *Fixed-effects models of FDI and BMI in the Chinese adult population 1993-2011*

Model	**(4.1)**		**(4.2)**	
Method	**Regional FDI**		**Adjusted FDI**	
Variables	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Regional FDI in year 2000 USD, logged	−0.025	(0.075)		
WF in millions of 2000 USD, logged			1.323***	(0.397)
ln(lagged GRP, constant 2000 USD)	1.049***	(0.340)	0.556	(0.354)
logged regional population, 10000s	−0.184	(0.868)	−0.225	(0.870)
% of regional population with vocational education or lower	0.032***	(0.012)	0.015	(0.013)
Size of household	−0.021	(0.019)	−0.021	(0.019)
2nd asset quintile	−0.094	(0.098)	−0.094	(0.098)
3rd asset quintile	−0.181*	(0.105)	−0.182*	(0.105)
4th asset quintile	0.163*	(0.093)	0.162*	(0.093)
5th asset quintile (wealthiest)	0.378***	(0.108)	0.377***	(0.108)
Age	0.219***	(0.008)	0.219***	(0.008)
Age squared	−0.002***	(<0.01)	−0.002***	(<0.01)
Gender (0 = female)	−0.155***	(0.060)	−0.155***	(0.060)
Nationality (= 1 if not Han)	−0.233	(0.154)	−0.236	(0.154)
Urban (1 = Urban)	0.533***	(0.102)	0.533***	(0.102)
Constant	6.213	(15.411)	−1.261	(0.291)
Observations	56319		56,319	
R-squared	0.132		0.133	

*Notes: P-values are heteroskedasticity robust; *** p<0.01, ** p<0.05, * p<0.1*

25^{th} percentile of BMI was found. Similarly, F-tests for the 50^{th} vs. the 75^{th} quantile estimates, 25^{th} vs. 75^{th}, and for equality of all three were calculated to be 0.01, 0.42, and 0.33. Consequently, the inter-quartile regression analysis supported the idea that the association between **WF** and BMI was uniform across all BMI levels. The bootstrapped median regression is reported in Model 4.6. This indicated that the regressions estimated with *qreg2* were consistent with those estimated using Stata's in-built commands. Finally, when comparing Models 4.6 and 4.4, cluster-robust standard errors were larger than those for the bootstrapped estimation. This, in conjunction with the results of the Parente & Santos Silva (2016) F-tests for intra-cluster correlation, indicated that adjusting for clustering was necessary, and that the standard errors for the bootstrapped median estimate should be interpreted with care as a result (Greene, 2003; Wooldridge, 2002).

Figure 4.2 illustrates that the coefficients associated with **WF**, at different conditional BMI quantiles. These coefficients remain insignificantly different from the OLS coefficient of 1.176 throughout. The coefficient associated with regional FDI (used in place of **WF** in an otherwise identically specified model) remained statistically insignificant throughout the BMI distribution, with the exception of the range between the median and 53^{rd} percentile estimates (See Appendix Figure C.1). Between these percentiles, the coefficient estimate for regional FDI in association with BMI was approximately 0.116 throughout.

Table 4.3: *Quantile regressions of **WF** and BMI in the Chinese adult population 1993-2011*

Model	**(4.3)**		**(4.4)**		**(4.5)**		**(4.6)**	
Method	*simultaneous quant. regression (25th percentile)*		*simultaneous qreg (Median)*		*simultaneous qreg (75th Percentile)*		*Bootstrapped qreg (median)*	
	Coef.	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Exposure to FDI in millions of 2000 USD, logged	1.426***	-0.434	1.176***	-0.441	1.138**	-0.539	1.176***	-0.332
ln(lagged GRP, constant 2000 USD)	0.753**	-0.329	0.873***	-0.309	1.070**	-0.453	0.873***	-0.258
logged regional population, 10000s	-0.2	-0.9	-0.059	-0.873	-1.818	-1.186	-0.059	-0.748
% of regional population with highest education of vocational	0.004	-0.014	0.012	-0.011	0.019	-0.018	0.012	-0.01
Size of household	-0.029	-0.018	-0.029	-0.019	-0.019	-0.022	-0.029***	-0.009
2nd asset quintile	-0.167**	-0.085	-0.111	-0.098	-0.071	-0.134	-0.111**	-0.048
3rd asset quintile	-0.195**	-0.087	-0.164	-0.1	-0.208	-0.139	-0.164***	-0.05
4th asset quintile	0.057	-0.088	0.197**	-0.098	0.287**	-0.131	0.197***	-0.05
5th asset quintile (wealthiest)	0.241***	-0.086	0.412***	-0.101	0.467***	-0.145	0.412***	-0.048
age	0.200***	-0.008	0.223***	-0.009	0.236***	-0.011	0.223***	-0.005
Age squared	-0.002***	(<.001)	-0.002***	(<.001)	-0.002***	(<.001)	-0.002***	(<.001)
Gender (0 = female)	0.03	-0.058	-0.078	-0.063	-0.307***	-0.079	-0.078**	-0.03
Nationality (= 1 if not Han)	-0.091	-0.126	-0.219	-0.152	-0.289	-0.183	-0.219***	-0.053
Urban (1 = Urban)	0.419***	-0.082	0.535***	-0.099	0.661***	-0.135	0.535***	-0.037
Constant	-4.678	-16.392	-5.677	-15.705	24.282	-21.541	-5.677	-13.232
Observations	56319		56319		56319		56319	
Pseudo R-squared	0.127		0.132		0.131		-	
Intra-cluster correlation	54.72 (<0.01)		73.44 (<0.01)		75.99 (<0.01)		-	

*Notes: P-values are heteroskedasticity robust; *** p<0.01, ** p<0.05, * p<0.1*
Cluter-robust standard errors in parentheses
Model 4.6 S.Es estimated using 5000 non-parametric bootstraps

4.5 Discussion

4.5.1 Principal findings

Model 4.2 (Table 4.2) suggests that for 15,825 CHNS respondents during the 1993-2011 period, the regional level of FDI plus spatially weighted FDI to other regions (**WF**) was associated with increases in individual level BMI across nine regions of China. This contrasts Model 4.1, which did not indicate the existence of any association between “unweighted" FDI and BMI. The difference in result underlines the importance of allowing for the impacts of FDI to extend beyond regional boundaries, leading to the compounding of the impact in smaller contiguous regions in receipt of large FDI inflows (Coughlin & Segev, 2000; Sharma *et al.*, 2014). This factor was sufficient to mask the ‘true’ association between FDI and BMI in China, when neglecting to take inter-regional diffusion of effects into account.

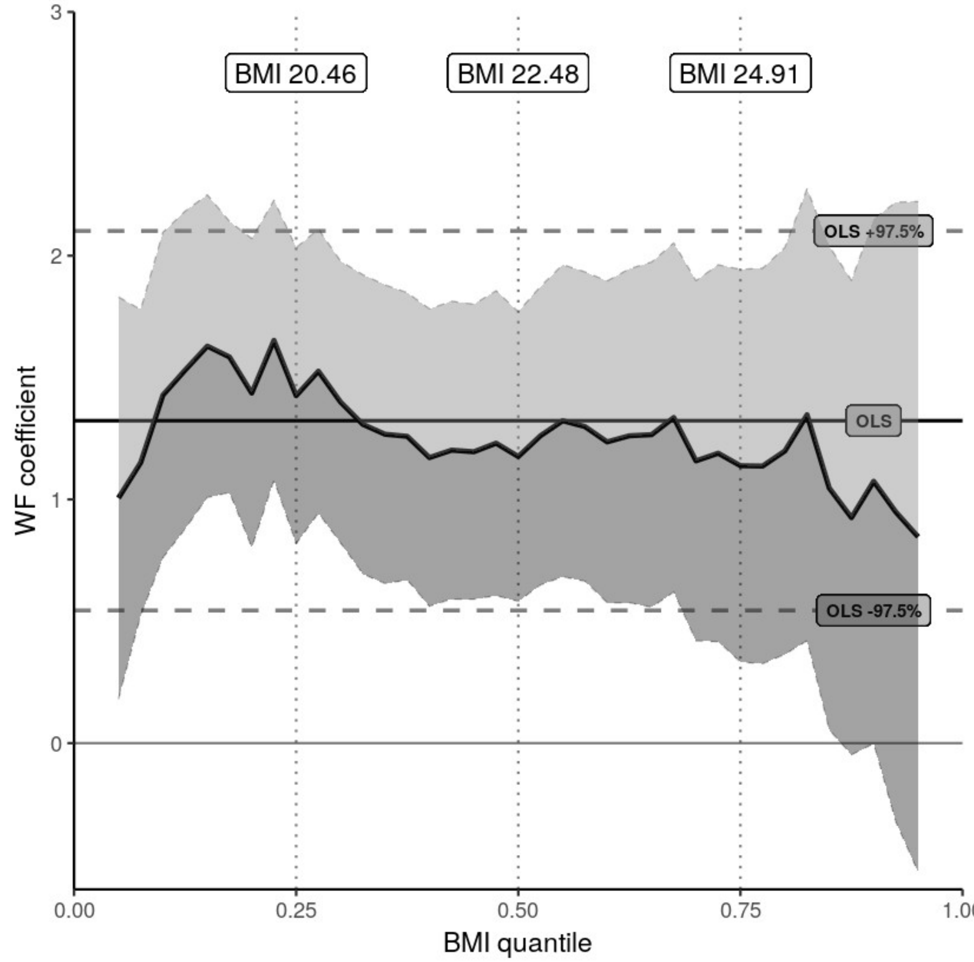


Figure 4.2: *Multiple quantile regression of* ***WF*** *and BMI in the Chinese adult population*

The ways that FDI in one region can influence nutritional health in other regions is a topic that has received relatively little attention. However, a few of the mechanisms by which FDI in one region have been previously linked with economic effects in other regions may be relevant (Coughlin & Segev, 2000; Sharma *et al.*, 2014). Increased growth as a result of FDI in other regions could lead to changes in income, which could then have a knock-on effect on nutritional health. Further, as discussed in Section 1.1.2, a firm may wish to invest in order to gain a platform on which they can engage with an otherwise inaccessible trade network. In China, over the 1992-2011 period, the number of special economic zones (SEZs) increased dramatically. in SEZs, foreign investors are provided incentives to invest, and their investments do not have to be approved directly by the Chinese government increased dramatically. The emergence of SEZs coincided with the historic increases in FDI to China (Wang, 2013). FDI entering a SEZ is likely to result in goods, services, or marketing efforts being distributed to other areas in China or south-east Asia. Therefore, due to the subsequent effect on markets for food in other regions, this may be a mechanism through which FDI in one region can affect nutritional health in another.

The magnitude of the estimated association between **WF** and BMI in Chinese adults is worthy of consideration. Between the 2006 and 2011 CHNS waves, FDI inflows rose by a mean value of 170% in constant-year 2000 USD. Model 4.2 therefore suggested that this increase was associated with an increase in population mean BMI of 2.25 kg/m2 in the Chinese adult population, when holding other factors constant. According to Model 4.4, the same increase in **WF** was estimated to be associated with a consistent BMI increase of 2.01 kg/m2 at every percentile between the 10^{th} and 90^{th}, above which point the coefficient for **WF** becomes insignificantly different from zero. The findings therefore indicated that **WF** has had, in isolation, a noticeable positive association with the BMI of the sample population. For instance, an increase in BMI of 2 kg/m2 for a Chinese adult male of mean height and weight within the estimation sample (166.58cm, 63.78kg) would be associated with a 5.55kg increase in weight over the 5 years between 2006 and 2011.

F-tests with the null hypothesis of equality of the 25th, 50th and 75th quantile estimations in any permutation could not be rejected, and in Figure 4.2, the coefficient of FDI exposure does not appear to vary based on the conditional quantile of BMI being estimated. When considering these results together, they suggest that increasing **WF** is associated with a shift to the right of the entire BMI distribution within the Chinese adult population, without a change in its distributional shape. Interpreted directly, this implies that while FDI appears to be bad for nutritional health in the sense that it increases the risk of obesity among those that are at normal or above normal weight. However, it appears to be beneficial to those at the low end of the BMI scale, in that it reduces their risk of underweight. In the sample used in this analysis, the prevalence of underweight was 6.67% — considerably less than those affected by overweight and obesity (34.54% and 7.91%, respectively), but still a sizeable portion of the large Chinese population (see Appendix Figure C.2 for the distribution of BMI in the CHNS sample used).(Conde & Monteiro, 2014; Shrimpton & Rokx, 2013). Du *et al.* (2014) indicate that underweight may be a smaller problem in China today, due to a downward trend in under-nutrition and a deviation away from entirely grain-based diets since the early 1990s. Yet, the authors found that even in 1992 — at the start of the period covered by this chapter's dataset, and when individuals began to move to urban areas to participate in the service sector — the prevalence of underweight was still over 8% in urban areas. As this chapter suggests that the FDI exposure affects underweight and overweight individuals' level of BMI equally (the extremes notwithstanding) it is therefore likely that a small subgroup of the population (those that are slightly underweight) has a beneficial association between FDI and nutritional health.

4.5.2 Strengths and Limitations

The models in this chapter are estimated using a large sample of individuals, living in nine different Chinese regions across a period of 18 years. The models included a range of control variables, comprising individual, household and regional characteristics, regional and time dummy variables and standard errors which were robust to community level clustering. The findings in this chapter provide robust evidence of an association between the regional level of exposure to FDI in China and individual BMI. The methodological approach drew from literature on the spatial diffusion of FDI economic impacts, and applied these techniques — for the first time — to the context of FDI and health in LMICs. Doing so made a significant difference in terms of uncovering the association between FDI and BMI in Chinese adults, highlighting the importance of taking spatial diffusion of FDI impacts into consideration when deciding an appropriate econometric approach. Failing to adjust for spatial diffusion of FDI impacts can lead to socioeconomic determinants of health remaining undetected by researchers because of measurement error.

Straight line distance is undeniably a simplification of geographical barriers to trade which may limit the spatial diffusion of FDI's impact from one Chinese region to another. However, the models also included fixed effects for region, which then controlled for time-invariant factors, including levels of physical accessibility, or cultural effects on BMI and FDI.

The quality and reliability of data from official Chinese sources, which was used in this chapter for regional economic data, have been called into question in the past, implicating measurement error, which could then be influencing the estimated association between FDI and BMI. However, recent assessments of the accuracy of the data used in Chapter 4, by Chow (2006), have indicated that Chinese data published after 1990 is accurate, when compared to equivalent independently collected data. As the study sample in Chapter 4 covered the 1993-2011 period, measurement errors are less likely to be a factor influencing the findings.

The CHNS did not cover all 31 mainland regions of China, and all the regions included were on the eastern half of the country (See Figure 4.1). The findings within this chapter may therefore chiefly represent the nutritional health impact of FDI in eastern regions, which are incidentally the regions which have received the most FDI historically. Consequently, the results may not necessarily carry over to the entire Chinese population, because there may be significant and systematic differences in population nutritional health and its determinants in the more westerly regions, which this chapter does not account for.

This chapter may have been limited in its ability to fully describe the association between FDI and BMI in the Chinese population, due to the aggregated nature of the FDI data available. Data with finer geographic detail, along with simultaneously geographically and industrially disaggregated data were not available for investigation. Future studies into the impact of FDI on nutritional health in China should seek to utilise more geographically detailed and representative datasets, following from the work of Blanc-Brude *et al.* (2014), or potentially even explore health impacts of FDI in specific industrial sectors, including food, beverages and tobacco, or manufacturing (See Figure 3.1, Section 3.1 and Section 3.4.3) (Moran, 2011). This may help to address the possibility that this analysis is subject to aggregation bias. In particular, studies into comparison of eastern and western China, studies including data from both sides, or studies attempting to adjust for aggregation bias would be valuable.

The association between FDI arriving in a region and the effect which this has on nutritional health is likely to be a dynamic one. That is, the effect of FDI on nutritional health is likely to manifest over time. There may be a stronger association between FDI in one period, and nutritional health in a later period. Therefore, a dynamic model specification, including FDI from previous years, would have been preferable, to capture the gradual nature of the likely effect which FDI has on BMI in Chinese adults. However, the CHNS surveys were not conducted at sequential or consistent time intervals, meaning that lagged variables would not always be lagged by the same amount of time. Consequently, a dynamic specification would have been highly likely to generate biased results.

Chapter 3 addressed the possibility of endogeneity when investigating FDI impacts on health in the cross-country context (see 2.4.2 and Figure 3.1). Reverse causality, or the ability of an individual's BMI to influence regional FDI inflows, is unlikely to be an issue in the same sense as in Chapter 3. However, endogeneity can also be caused by unobserved heterogeneity, and to account for this, household and individual covariates were included, alongside time dummy variables, regional dummy variables and lags of regional GRP (Angrist & Pischke, 2008; Wooldridge, 2002).

Finally, many changes took place in China during the 1993-2011 period. Although an effort was made to take important factors like changing incomes, assets, time trends and others into consideration, the possibility cannot be entirely discounted that certain factors (e.g. societal change) have been excluded that ought to have been adjusted for. Hence, the results from the regression models should be considered with this caveat in mind.

4.6 Conclusions

Regression analysis indicates that the BMI of the Chinese adult population has been affected by levels of FDI exposure over time, and that these effects are not negligible. The models in this chapter indicate that during the 170% real-terms increase in FDI inflows to Chinese regions during the 1993-2011 period, mean BMI has increased by 2.25 kg/m^2 and median BMI has increased by 2.01 kg/m^2, owing to FDI. Further, regression analysis simply incorporating regional levels of FDI fails to identify an association, highlighting the probable importance of FDI geography to its health impacts within an individual LMIC. Future efforts to track the association between trade or investment policy and levels of international investment should incorporate some investigation of whether geographical factors play a role.

The effect of FDI on BMI in Chinese adults appears to be uniform, with those at all positions in the BMI distribution being equally affected in terms of BMI. However, due to the geographic coverage of the China Health and Nutritional Survey, these results over-represent the eastern population, meaning that further research is required to establish what the influence of FDI may be on the nutritional health of those populations.

This chapter focused on the association between FDI and health in China, and utilised large-scale individual level longitudinal datasets to both avoid endogeneity issues and explore individual outcomes. It also incorporated, for the first time, a geographic element into research on FDI and population health. This investigation provided insight into the influence which FDI may have on the nutritional health outcomes of Chinese adults, suggesting a uniform shift to the right of the whole BMI distribution as a result of FDI in nine Chinese regions, 1993-2011. Overall, this is a mixed effect comprised of harm to those that are already overweight, and benefit to those that are underweight. Chapter 3 implied that the overall effect of FDI in LMICs is a positive one, but also hinted that there may be some damaging associations within. Chapter 4 therefore provides some support for that.

Changes in BMI are most likely the result of underlying changes in health-related behaviours, which themselves can be determined by changes in environments, resources and opportunities. All of these factors can be influenced by FDI, as it brings with it more supply, lower prices, more jobs and more variety of available goods. Yet, this chapter provides little insight into whether FDI should be considered to be a socioeconomic determinant of health behaviours in LMICs. Consequently, Chapter 5 attempts to address this through investigation of FDI and health behaviours. More specifically, Chapter 5 looks at the association between FDI and smoking in Russian adults, 2011-2014.

CHAPTER 5

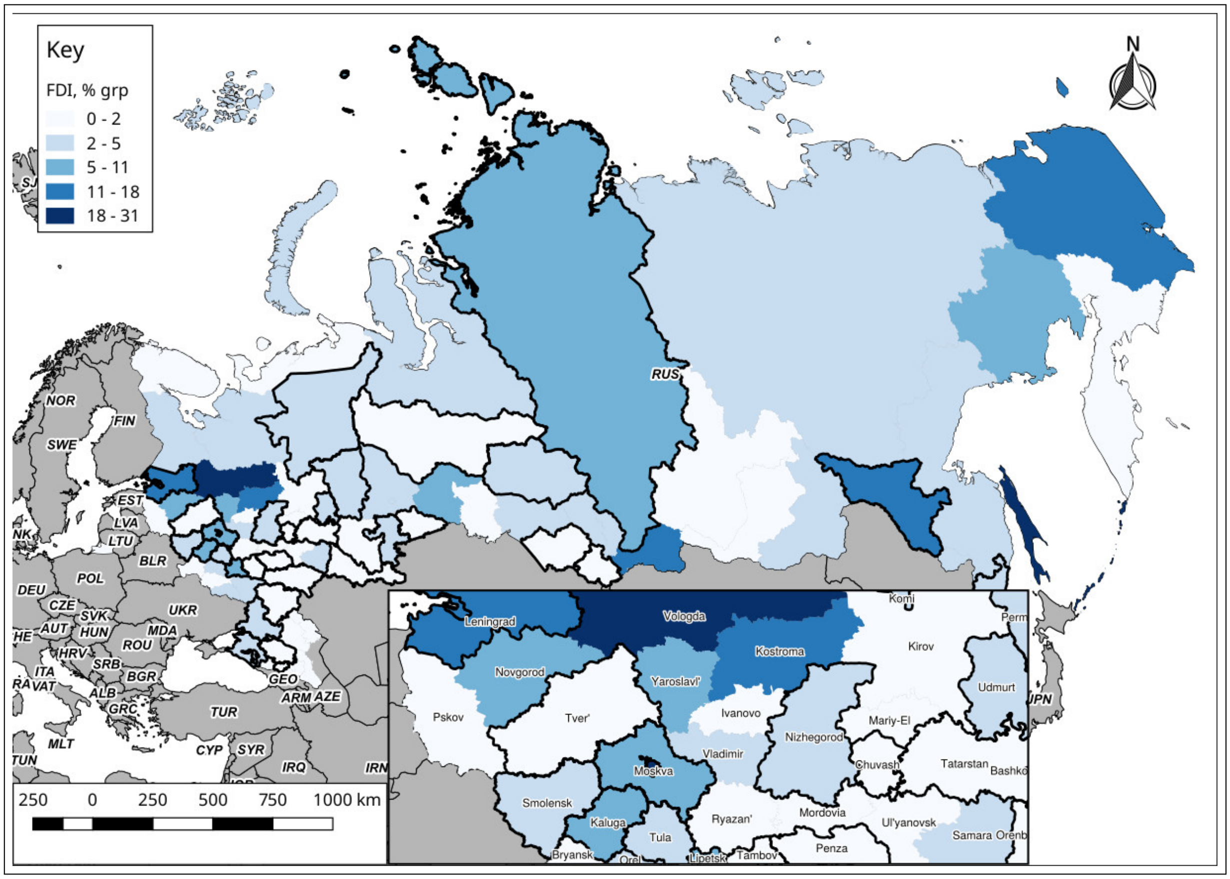
Regional Exposure to Foreign Direct Investment and Health Behaviours in Russia

5.1 Introduction

The prevalence of smoking among Russian adults is currently estimated to be 53.3% in males and 16.1% in females WHO (2016). This is recognized to be a contributory factor in high adult mortality, particularly within Russian men Notzon (1998); Zaridze *et al.* (2009). Despite this, male and female smoking prevalence is rising in Russia over time, emphasizing the need to investigate the potential causal mechanisms involved Perlman *et al.* (2007).

The privatisation of the Russian tobacco industry in the 1990s allowed the entry of foreign firms into the market, and subsequently led to increasing FDI inflows. It has been suggested that the influx of foreign firms, branding and advertising of tobacco and tobacco products may have driven increases in smoking prevalence and tobacco consumption Gilmore *et al.* (2011); Perlman *et al.* (2007). Gilmore & McKee (2005), when exploring statistics on smoking prevalence and FDI in former Soviet Union countries, suggest a positive link with tobacco industry FDI (OECD, 2008). This analysis was descriptive, and the authors refrained from statistically examining the links between FDI and smoking. Further, Gilmore & McKee (2005) acknowledged problems with measurement error during the 1990s through individuals transitioning from illegally acquired (thus unobservable in their study design) cheaper foreign-made cigarettes to legally acquired foreign-made cigarettes. Despite these limitations, their article does highlight a potential link between FDI and smoking behaviours. In order to expand on this previous work, Chapter 5 comprises an econometric study aiming to test the hypothesis that FDI is a socio-economic driver of smoking behaviours amongst Russian adults. Support for this hypothesis would take the form of a positive statistical association between quantities of FDI and smoking behaviours, after controlling for other factors.

One complicating factor when empirically investigating FDI and smoking in Russia is the possibility that FDI effects diffuse spatially, both between regions within a country and across international borders, as discussed in Section 4.2.2 (Blonigen *et al.*, 2007; Sharma *et al.*, 2014). In chapter 4, this factor was taken into account using an FDI measure which was adjusted for FDI flows to other regions, and straight-line distances between regions. Regression models suggested this measure to be associated with BMI, whilst models estimated using a simple measure of regional FDI did not identify any association. Yet, this investigation did not extend to the association between FDI and individual health behaviours like smoking. Consequently, it is unclear from current evidence whether or not regional FDI is a socio-economic determinant of health behaviours, and whether or not spatial diffusion is a factor. To address this, Chapter 5 takes the form of a case-study of FDI and smoking in Russia.



Key:
Regions outlined in bold are those included in the RLMS
FDI in Russia is highly concentrated in Moscow City and St. Petersburg

Figure 5.1: *Regional FDI in the Russian Federation, 2011-2014*

It can be seen through visual comparison of Figures 4.1 and 5.1 that FDI inflows to Russia are even more geographically concentrated on the regional scale than in China, and are not concentrated along the coastline (Bradshaw, 1997, 2002; Iwasaki & Suganuma, 2015, 2005). Factors like spatial diffusion of FDI impacts on population health or health behaviours are consequently likely to be more important, as there are more regions which do not receive large inflows themselves, but border a region which does. A similar strategy to Chapter 4 was therefore used to incorporate spatial information into the analysis for Chapter 5.

The combination of regional economic data and longitudinal household data provides an opportunity to conduct a case study of rising FDI and the influence this may have had on smoking within Russia's adult population.

The aims of Chapter 5 were to investigate the association between regional levels of FDI and smoking in the Russian adult population using econometric methods, and to investigate the importance of controlling for spatial diffusion of FDI effects, similarly to Chapter 4.

5.2 Data

5.1 lists the data sources and descriptive characteristics of all the variables used in this chapter. To empirically examine whether regional exposure to FDI in Russia is related to smoking prevalence or cigarette consumption levels, individual level panel data from 33 regions of Russia over the period 2011-2014 was used, taken from the 20th to 24th waves of the Russia Longitudinal Monitoring Survey (RLMS) (Kozyreva *et al.*, 2016). Survey questions included detailed information on individuals' demographics, physical attributes and health behaviours, household characteristics including household assets, and finally community level information. Consequently, the RLMS provided a comprehensive set of control variables for an econometric investigation, and this information was utilised throughout the study. Control variables which were not available from the RLMS, including regional and national economic indicators (e.g. FDI, GDP, population), were collected directly from the Central Bank of Russia website, or from the Knoema website, which has collated a wide range of Russian official datasets directly from Federal State Statistics Service of Russia (Rosstat) sources, which are largely not available from source in English (Knoema, 2016; Rosstat, 2014). Where possible, checks were made to corroborate the information from Knoema with accessible sources from Rosstat.

5.2.1 Outcome Variable

To investigate whether exposure to FDI is related to smoking in Russia, responses to the survey questions "Do you currently smoke?", and "About how many individual cigarettes or papyroses (unfiltered cigarettes) do you usually smoke in a day?" were collected from the 2011-2014 (20^{th}-24^{th}) waves of the RLMS.

5.2.2 Predictor Variable

Data on FDI inflows in current millions of Roubles to each Russian republic, region, Kraj, Oblast and city 2011-2014 was collected from the Central Bank of Russia (2016a) (CBR) website. The impacts of FDI are unlikely to be completely spatially arrested by administrative borders within a country, as discussed at length in Chapter 4 (Blanc-Brude *et al.*, 2014; Coughlin & Segev, 2000; Iwasaki & Suganuma, 2005). The same strategy as in Chapter 4 was used to adjust for spatial diffusion of FDI effects in Chapter 5 (See Section 4.3.1). Approximately 30% of FDI to Russia was made up of food, tobacco, beverage production and wholesale trade in the 2010 to 2014 period (See Table D.2), suggesting that aggregate FDI is likely to be a reasonable proxy for tobacco industry FDI (Central Bank of Russia, 2016b).

5.2.3 Regional covariates

Gross regional product per capita

Regional levels of income are likely to confound the relationship between regional FDI, smoking rates, and the amount of cigarettes that people smoke (Kostova *et al.*, 2014). Consequently, regional levels of income via gross regional product (GRP) in constant year 2010 US Dollars was included in all estimations. One complicating factor was that regional levels of income and FDI are likely to be interrelated owing to higher investment interest in wealthier regions, as well as the impact of FDI on regional wealth. In order to reduce the extent to which this could bias the estimation of the FDI and smoking association in Russia, GRP was lagged by 1 year in all regressions.

Price of a 10 pack of cigarettes

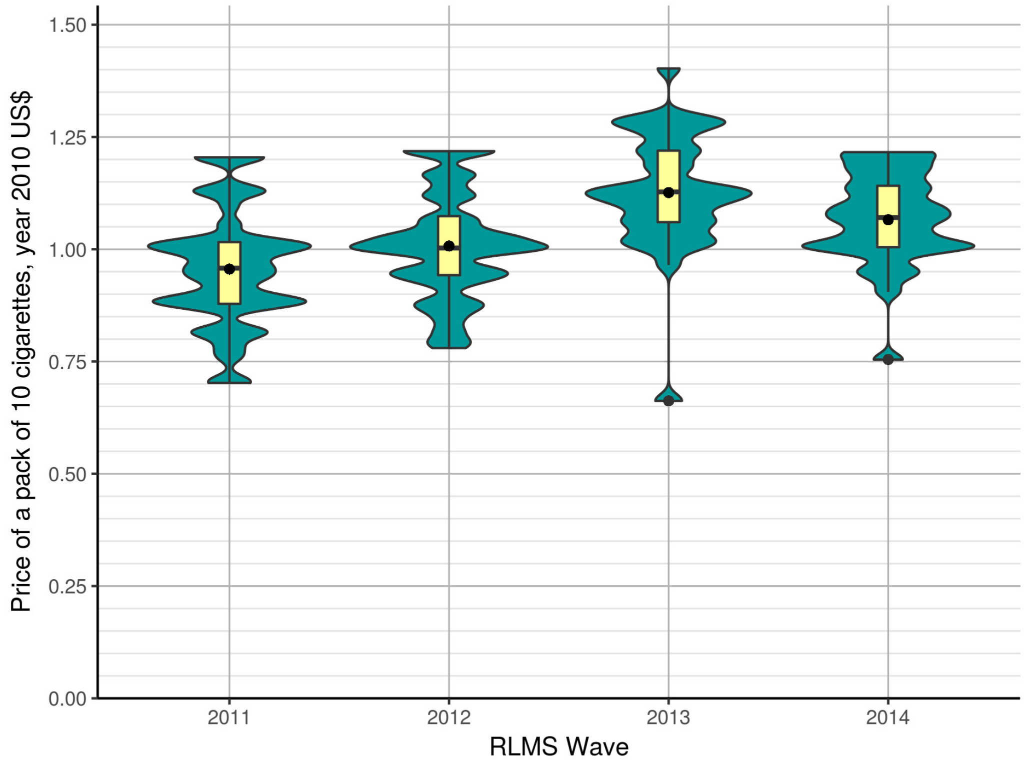
Some studies have indicated that in Russia, demand for cigarettes is relatively price inelastic, but not so inelastic as to render price unimportant (Lance *et al.*, 2004). In support of this, one recent study by Herzfeld *et al.* (2011, 2014) reported price elasticity of demand of cigarettes in Russia to be -0.12 for adult men and -0.17 for adult women. The price of cigarettes may affect both the number of smokers, and the number of cigarettes smoked per day, and is therefore a potentially important factor in determining the levels of the dependant variable in this investigation. Inspection of the RLMS data revealed that when aggregating individually reported cigarette pack prices (only reported by smokers) to the 34 regions in which data was collected, pack prices have fluctuated

Table 5.1: *Descriptive statistics of variables used in Chapter 5*

Variables	n	Mean (%)	S.D.	Min	Max
Outcomes					
Smoking prevalence	55974	42.90%	-	-	-
Cigarettes per day among smokers	55974	15.9	8.13	1	80
Regional covariates					
FDI (%GRP)	132	6.3	8.78	0	47.21
WF (%GRP)	132	15.44	14.59	3.02	65.48
GRP, millions of 2010 USD, lagged	132	14077.8	20834.43	886.04	149499.89
Regional population, 100,000s	132	32.66	30.15	2.08	121.53
Regional mean reported price of 10 cigarettes	132	1.03	0.14	0.66	1.4
Household covariates					
Household size	6500	3.31	1.61	1	11
1st Asset Quintile	2193	33.74%			
2nd Asset Quintile	1224	18.83%	-	-	-
3rd Asset Quintile	1324	20.37%	-	-	-
4th Asset Quintile	749	11.52%	-	-	-
5th Asset Quintile (highest)	1010	15.54%	-	-	-
Individual covariates					
Age	55974	46.26	17.68	18	101
Male	23386	41.80%	-	-	-
Non-Russian	8110	14.50%	-	-	-
PGT	3798	6.79%	-	-	-
Rural	15210	27.17%	-	-	-
Unemployed	23040	41.20%	-	-	-
Secondary	7631	13.63%	-	-	-
Vocational	28918	51.66%	-	-	-
University or higher	14247	25.45%	-	-	-
Believer	47110	84.16%	-	-	-
Non-believer	7815	13.96%	-	-	-
Not married	26488	47.30%	-	-	-

Notes: For regional covariates, n describes the number of observations on the regional level For household covariates, n describes the number of observations on the household level household size and wealth are not mutually exclusive over time. Proportions presented are for 2011

significantly over the 2011-2014 period, even when controlling for regional inflation and converting Roubles to USD (See Figure 5.2). This also suggests that cigarette prices are an important consideration in this context. The price of cigarettes within a Russian region could also feasibly influence inflows of FDI, but this is likely to be a relatively minor consideration. Cigarette prices were therefore incorporated into the estimation strategy not to adjust for confounding, but to improve the precision of the estimated models. Regional mean cigarette price in constant year 2010 USD was included in all regressions. Regional means were used as non-smokers were not presented with the question of cigarette pack price, and aggregating on this level allowed for an appropriate measure of cigarette price level within each region included in the RLMS dataset.



Data for cigarette prices in Roubles is taken from individual responses to the question: "what is the price of a pack of 10 cigarettes" in the RLMS 2011-2014 waves, which was not asked to non-smokers. Regional means were then calculated ignoring the missing values from non-smokers. Width of violin plot is determined by frequency.

Figure 5.2: *Price of a pack of 10 cigarettes in constant year 2010 USD*

5.2.4 Household covariates

Household and individual covariates were included not to reduce confounding, but rather to increase the precision of the estimations. Household size in persons was included in all estimations, with the expectation that at least to some extent the size of households in Russia has been linked with some variation in health behaviours (Herzfeld *et al.*, 2011, 2014). In addition, information on household assets was used to proxy household wealth. An index was composed using principal component analysis, similarly to Chapter 4 (See Section 4.2.4). To estimate the index, guidelines provided by the World Bank on health and equity were followed (Filmer & Pritchett, 2001; O'Donnell & Doorslaer, 2008). Asset scoring estimations used information on ownership of electronics, household goods (washing machines, microwaves etc.), dacha (a small plot of land, usually with a small house on it), vehicles and home ownership. The factor function in Stata 13.1, with the option pcf, was used for this estimation (StataCorp, 2013). Descriptive statistics for the assets included in asset scoring calculations are provided in Appendix table D.1.

5.2.5 Individual characteristics

There are many individual characteristics which may drive both the decision to smoke, and how much to smoke, and there already exists a body literature focused on what these may be. To identify the relevant studies, a targeted literature search was performed (search terms are provided in Appendix D, and this search was supplemented with manual searching of grey literature). 19 studies focused on determinants of smoking were identified, five of which utilised data from Russia, or the RLMS dataset. McKee *et al.* (1998) was the earliest study found, and this focused on urban/rural status, levels of education, material deprivation and religion as covariates to explain patterns of smoking in Russia. Studies by Pärna *et al.* (2003), and Pomerleau *et al.* (2004) additionally considered marital status, age, nationality and household wealth. More recently, a multivariate logistic regression analysis by Hosseinpoor *et al.* (2011) considered a pooled sample of 213,817 people from 48 different LMICs. The authors found the important determinants to include marital status, education, employment, and household wealth (in the form of quintiles, similarly to those used in both Chapter 4 and Chapter 5). Finally, Herzfeld *et al.* (2014) considered a similar set of individual smoking determinants, with the additions of a squared measure of age to adjust for the non-linear association between age and smoking, and also adjusted for correlation between repeated measures from individuals via computation of cluster-robust standard errors.

Nationality, in the form of a dummy variable taking a value of 1 for those that are not of Russian descent, was included in all models, alongside the level of education (discussed further below), and urban/rural status. Many of the studies identified in the literature search included age and its squared term separately. However, the estimation method used in this chapter (discussed in section 5.3.3) does not converge in the presence of very highly correlated explanatory variables, and age is very highly correlated with age squared. Consequently, logged age was used as a compromise to at least partially control for the non-linear impact of age on smoking. Urban/rural status is measured as a multinomial in the RLMS data. Levels include urban, PGT (A large village with some infrastructure) and rural. Consequently, a set of dummy variables was included, with urban as the reference category.

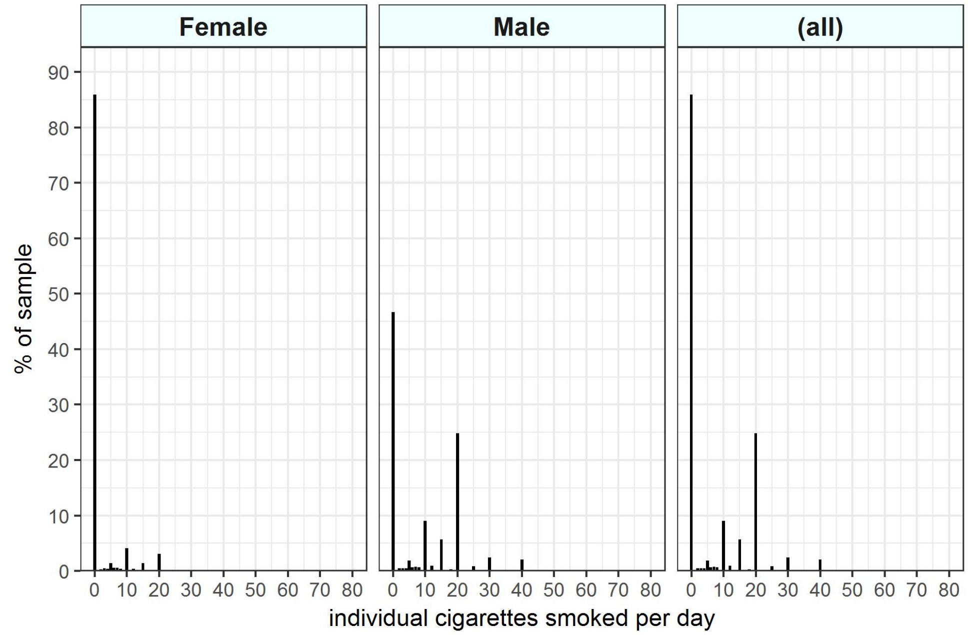
The work by Herzfeld *et al.* (2011, 2014) indicates that more educated individuals are generally likely to have lower consumption of cigarettes, depending on the country of focus. A measure of individual education was consequently included in all estimations. A set of dummy variables, dependent on an individual's level of education were used, including the levels: lower than secondary education; secondary education; vocational education; and university education or higher. Lower than secondary education was omitted from regressions, and was therefore the reference category.

5.3 Econometric approach

5.3.1 Treatment of smoking data, and stratification of the analysis

Combining responses from the two smoking questions from the RLMS which were used in Chapter 5 (Figure 5.3) revealed a fundamental difference in smoking behaviours between Russian men and women. The prevalence of smoking in Russian men was 51.16%, in contrast to the female prevalence of 14.63%. This indicated that even as recently as 2011-2014, there remained a significant difference in the prevalence of smoking by sex in Russia. In addition, the pattern of cigarette consumption amongst those that did smoke also varied by sex, with 56.57% of male smokers reported their consumption to be 20 cigarettes per day or more, whilst only 24.13% of women reported the same. Due to the pronounced sex differences in smoking behaviours within the Russian adult population, male and female smoking behaviours were investigated separately in Chapter 5. An analysis using a combined sample would primarily represent males, as the combined smoking data more closely represents male smoking behaviours (See Figure 5.3). Descriptive statistics for the individual level covariates used in Chapter 5, disaggregated by sex, are available in Tables D.3 and D.4.

Another complicating factor was the heaping of the response data, as can also be seen from Figure 5.3, Responses tended to be in multiples of 5 for both the male and female strata. This is likely a combination of two factors: the rounding of responses by respondents, and respondents actually consuming simple fractions like $\frac{1}{2}$ of a packet of cigarettes per day. The econometric implications of this issue are discussed further in Section 5.3.2. However, to



Notes: *Smoking responses are limited to those made by people aged between 18 and 100. Difference in frequency of responses at multiples of 5 demonstrates the extent of heaping in the data. This is discussed more in Section 5.3.2, and the data used in the analysis is presented in Figure 5.4*

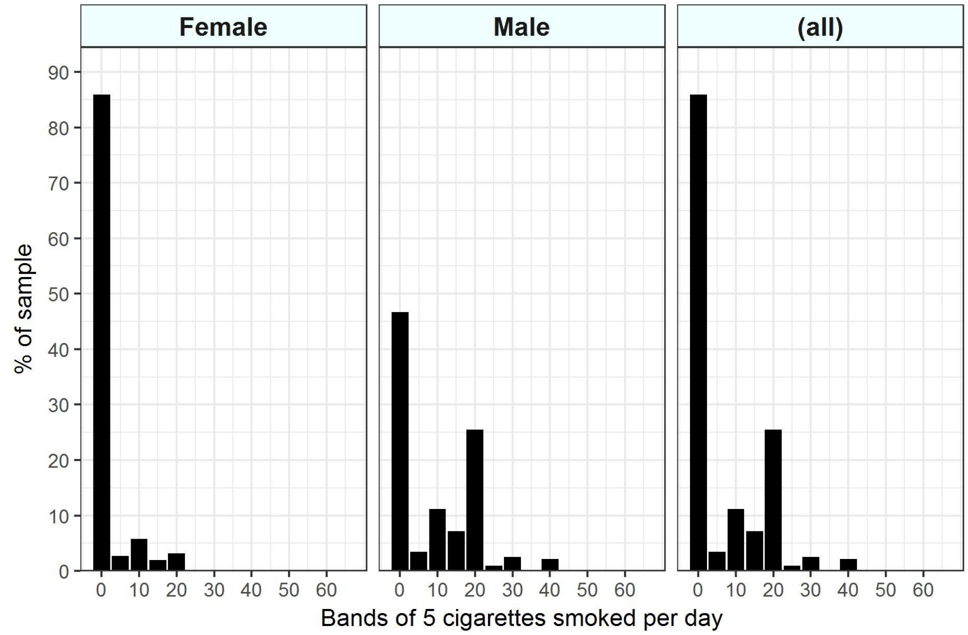
Figure 5.3: *Smoking by sex in the Chapter 5 sample*

accommodate this issue, cigarette consumption was measured simply in $\frac{1}{2}$ packs (i.e. bands of five cigarettes), similarly to a previous article on social capital and smoking in Germany139. Individual cigarette consumption responses in the RLMS were rounded to the nearest multiple of 5. This resulted in Figure 5.4, which retained a very similar distributional shape to the smoking data presented in Figure 5.3, and allowed a simpler interpretation of coefficients than any alternative approach.

5.3.2 Hurdle and Zero-inflated negative binomial (ZINB) models

Smoking as a health behaviour can be broken down into two decisions: the decision to smoke, and the decision on how much to smoke, given the affirmative decision to smoke (sometimes referred to as smoking intensity). Jones (1989) labelled these as the participation decision and the consumption decision in his seminal econometric analyses of cigarette consumption. To investigate only whether FDI is a socio-economic determinant of the smoking participation decision may be informative, but would also forego investigation of the association with the consumption decision. Consumption levels may also be an important aspect of the relationship between FDI and smoking in Russia. This is because of transnational tobacco companies use advertising and marketing in an attempt to boost market share when entering new markets, which may affect overall levels of smoking participation and tobacco consumption amongst smokers (López *et al.*, 2004; Saffer & Chaloupka, 2000).

There are a range of econometric approaches in a double-hurdle context, particularly with respect to modelling self-reported count data. Most of these are based on one of two techniques, which are quite similar in purpose and function. These are the zero-inflated negative binomial (ZINB) (and its many variants) and double-hurdle models (Greene, 2003; Jones, 2007). As discussed in Greene's book Econometric Analysis, and more extensively in Jones' book *Applied Econometrics for Health Economists: a Practical Guide*, both approaches use a two-part specification, with one model to estimate the probability (and therefore frequency) of a zero (or non-zero in the double-hurdle case) dependant variable, whilst the other part estimates the positive counts values (Greene, 2003; Jones, 2007).



Notes: *The variable was transformed so that 1-5 cigarettes per day corresponded to a value of 1, 6-10 to a value of 2, and so on. All reported consumption above 60 was placed in the same band.*

Figure 5.4: *Smoking by sex in the Russian adult population, 2011-2014, banded by groupings of 5 cigarettes per day*

The key difference between these approaches is that in the approach proposed in Jones, the binomial and count data are assumed to be generated by two separate generating processes, rather than the same underlying process, as in ZINB.

There have been many adaptations of these approaches to accommodate the nature of the underlying data. From Figure 5.3, it is clear that responses to the consumption survey question are much more frequent at multiples of five, and especially at 10 and 20 cigarettes per day. This is referred to in health econometrics and public health literatures as ‘heaping’ (Wang & Heitjan, 2008). This could be due to rounding of responses due to a combination of recall error, actual use of simple fractions (like $\frac{1}{2}$ a pack per day), and accommodation of the day to day fluctuations in consumption, as discussed in Section 5.3.1. Heaping is known to cause bias in the estimated coefficients of regression models, and to affect the precision of model fits (Cameron & Trivedi, 2005; Jones, 2007). Consequently, a data transformation to adjust for heaping, or a methodological adaptation, is required to avoid biased results.

5.3.3 Selected method

The objective of this chapter was to determine the existence of an association between FDI exposure and the participation and consumption decisions within the Russian population, and not to construct a comprehensive predictive Russia smoking model. Consequently, a hurdle approach was used. This econometric strategy allows useful inference of the coefficient of **WF** for both the participation and consumption decisions, whilst remaining straightforward to implement. Within the context of Chapter 5, the hurdle model assumes that the data generating process of the participation and consumption decisions (See Section 5.2.1) are separate, as described in Equation 5.1. In other words, the decision to be a smoker, although assumed to be determined by the same set of covariates in this chapter, does not directly influence the decision of how many cigarettes per day a smoker smokes.

$$f(y_{it}) = \begin{cases} f_1(0), & \text{if } y_{it} = 0 \\ \frac{1-f_1(0)}{1-f_2(0)} f_2(y_{it}), & \text{if } y_{it} > \ 0 \end{cases} \quad (5.1)$$

Where $f(y_{it})$ is the function to estimate y, $f_1(0)$ is the function to estimate the probability that , $f_2(0)$ is the function to estimate the count value of y_{it}, given that $y_{it} = 0$ (i.e. that y_{it} in the count model is truncated), $f_2(y_{it})$ is the function to estimate y, given that $y_{it} > 0$ (i.e. the y values that are not truncated). This form is used because the two models, $f_1(0)$ and $f_2(0)$ can take the form of any binomial and count regression model, respectively (e.g. logistic regression and Poisson regression, see Gujarati (2009) or Greene (2003) for specification of binomial and count models)

For this analysis, logistic regression was used for the participation decision (f_1 in Equation 5.1), and a Poisson model, truncated at 0/1, was used to capture the consumption decision (f_2). A wide range of estimation strategies can be employed when estimating hurdle models (Jackman *et al.*, 2015; Jones, 2007; Zeileis *et al.*, 2008). Yet, all combinations of these estimation methods produced very similar results in this case. Logistic and Poisson were preferred, due to low Akaike information criterion score, relatively high absolute value of log-likelihood, and the relative simplicity of their interpretation.

As both the logistic and Poisson models are non-linear, Model parameters are presented as estimated (i.e as their original β estimates). Logistic regression coefficients can be exponentiated to give an odds-ratio of the response being equal to 1 (or in this case an integer greater than zero), indicating a smoker. For the consumption decision (or the number of cigarettes consumed per day, given that the individual is a smoker), the poisson model can be described by Equation 5.2. The expected change in probability of being a smoker, or expected change cigarette consumption amongst smokers, associated with change in a particular variable, x_j (e.g. **WF**), depends on the levels of the other explanatory variables (Cameron & Trivedi, 2005; Kleiber & Zeileis, 2008). Typically, it is most useful to interpret the estimated coefficients generated in non-linear models in the form of marginal effects. These capture the expected change in y associated with a change in a variable, x_j, given a fixed set of characteristics (including x_j), which is termed here to be x^τ. Marginal effects are usually presented 'at the means', which is to say that x^τ is fixed at the mean level of each continuous variable, and a selected level of each categorical variable. Consequently, both the effect of a change in x_j on the expected probability that a 'typical' RLMS adult respondent is a smoker, and on the expected number of cigarettes consumed per day for a 'typical' smoker, can be estimated using Equation 5.3. This is a valuable metric, as it can be used to provide a sense of scale to the results. For instance, a range of observed values of **WF** can be used to estimate impacts on smoking behaviours in Russian adults. All models are reported with cluster-robust standard errors, clustered on the data collection site level.

$$E[y_{it}|\mathbf{x}_{it}] = e^{\mathbf{x}'_{it}\beta} \quad (5.2)$$

Table 5.2: *Individual characteristics of smokers and non-smokers in the RLMS, 2011-2014*

	Female		Male	
Smoking status	Non-smokers	Smokers	Non-smokers	Smokers
Mean age (SD)	49.71 (18.64)	39.35 (12.78)	45.78 (18.48)	41.65 (14.05)
Mean cigarettes per day (SD)	-	11.86 (6.7)	-	17.48 (8.12)
% Russian	85.76%	92.75%	83.21%	87.25%
% Urban	65.36%	75.18%	66.25%	63.75%
% PGT	7.19%	4.40%	7.14%	6.53%
% Rural	27.46%	20.42%	26.61%	29.72%
% Employed	51.36%	67.86%	60.73%	70.49%
% Believer	91.56%	86.73%	76.03%	73.80%
% University or higher	29.03%	19.09%	30.18%	15.67%

$$\frac{\delta E[y|\mathbf{x}^{\tau}]}{\delta \mathbf{x}_j} = f((\mathbf{x}^{\tau})'\beta).\beta_j \tag{5.3}$$

Where: x_j is the variable of interest, β_j is the coefficient estimate for that variable, $f(x'b)$ is the nonlinear function of $x'b$ which is used to capture the association between x and y

5.4 Results

As discussed earlier, there were distinct differences in smoking behaviours between Russian males and females within the RLMS, leading to the stratification of the analysis. Table 5.2 shows that other individual covariates were broadly similar.

5.4.1 Males

53.52% of males over 18 reported current smoking in the 2011-2014 waves of the RLMS. Amongst these, 57.78% self reported to smoke 20 or more cigarettes per day. Table 5.3 includes the results of Models 5.1 and 5.2, which are two hurdle models of regional FDI in Russia and smoking 2011-2014. Model 5.1 uses simply regional FDI to measure exposure (in both the logit and Poisson parts), whilst model 5.2 includes **WF** as calculated in Equations 4.1 and 4.4.

In model 5.1, the odds ratio for regional FDI in association with the participation decision was 0.997. The cluster-robust standard error of the regression coefficient (-0.003) was 0.004. Model 5.1 does not, therefore, indicate any association between regional levels of FDI and the participation decision for smoking in Russia. The same is true of the consumption decision, with an FDI coefficient of 0.002 (OR 1.002), and cluster-robust standard error of 0.002. Model 5.2

uses **WF** as a measure of regional exposure to FDI, the results were similar with respect to the participation decision. The coefficient of **WF** in the logit model was -0.001, (OR 0.999) with a respective cluster-robust standard error of 0.0025. This also does not suggest any association between FDI and the participation decision amongst Russian men. Finally, the coefficient of **WF** with respect to the consumption decision was 0.003 (OR 1.003), with a cluster-robust standard error of 0.001 (P=0.013). This indicated that an increase in **WF** of 1% of GRP corresponded to a 0.003 increase in the log count (the natural logarithm of the number of cigarettes smoked per day) (Kleiber & Zeileis, 2008) (See Equation D.1).

To put this into context, someone that smokes would be expected to increase consumption by 0.29% for a 1% of GRP increase in WF, all else being equal. However, due to the non-linear study design, greater changes in FDI (as a percentage of GDP) would not be expected to correspond to a linearly greater change in cigarette consumption. Further, as the estimated change is proportional, the effect on the actual amount of cigarettes consumed per day depends on the initial level of consumption. For instance, when estimating the change in expected consumption for a difference in FDI of 62.46% of GRP (the entire range of **WF** 2011-2014, see Appendix table D.2), the estimated difference in consumption would be 19.74%. At the modal consumption level of 20, this would correspond to a 3.947 difference in the number of cigarettes per day smoked by the average male over 18 smoker as a result of exposure to FDI in Russia.

5.4.2 Females

14.13% of females over 18 in the 2011-2014 RLMS waves reported current smoking. Amongst these, only 22.72% self-reported to smoke 20 or more cigarettes per day, much less than Russian men. The modal level of smoking amongst female smokers over 18 was 10, with 28.98% of female smokers in the sample reporting consumption of 10 cigarettes per day.

Table 5.4 lists the results of Models 5.3 and 5.4. In Model 5.3 and for the participation decision, the estimated coefficient for regional FDI was 0.024 (OR 1.024). The cluster-robust standard error was estimated to be 0.007, giving a P-value of 0.001. Model 5.3 therefore indicates a positive association between regional FDI and the participation decision for smoking in Russian women, even without taking into account the additional exposure as a result of FDI to surrounding regions. The same is not true of the consumption decision, however, which has an FDI coefficient of 0.001 (OR 1.001), and cluster-robust standard error of 0.002. This does not suggest any association between regional FDI in Russia — before taking spatial diffusion of FDI effects between regions into account — and the consumption decision for women that smoke.

Conversely, Model 5.4, which does take spatial diffusion of FDI effects into account, suggests an association between **WF** and both the participation and consumption decisions. The coefficient for **WF** was estimated to be 0.019 (OR 1.019), with a respective cluster-robust standard error of 0.004. This suggested that a 1% increase in **WF** was associated with a 0.019 increase in the odds

Table 5.3: *Hurdle regressions of FDI, **WF** and smoking in Russian Men, 2011-2014*

Model	**(5.1)**				**(5.2)**			
Part	**Binomial**		**Count**		**Binomial**		**Count**	
Exposure measure	**Regional FDI**				**Spatially weighted FDI (WF)**			
Value	β	**S.E.**	β	**S.E.**	β	**S.E.**	β	**S.E.**
Regional Covariates								
FDI (%GRP)	-0.003	(0.004)	0.002	(0.002)				
WF (%GRP)					-0.001	(0.003)	0.003**	(0.001)
ln(lagged GRP)	0.076**	(0.031)	0.012	(0.014)	0.076**	(0.031)	0.009	(0.013)
ln(regional population)	0.129*	(0.069)	0.01	(0.025)	0.125*	(0.071)	-0.004	(0.025)
Cigarette prices (USD)	-0.36	(0.256)	-0.127	(0.118)	-0.381	(0.253)	-0.198*	(0.115)
Household Covariates								
Household size	0.068***	(0.016)	0.002	(0.006)	0.068***	(0.016)	0.002	(0.006)
2nd Asset Quintile	-0.327***	(0.056)	0.009	(0.017)	-0.327***	(0.056)	0.011	(0.017)
3rd Asset Quintile	-0.349***	(0.078)	0.028	(0.019)	-0.350***	(0.078)	0.029	(0.019)
4th Asset Quintile	-0.566***	(0.089)	0.021	(0.023)	-0.566***	(0.089)	0.021	(0.023)
5th Asset Quintile	-0.494***	(0.086)	0.016	(0.019)	-0.497***	(0.085)	0.016	(0.019)
Individual Covariates								
ln(age)	-0.285***	(0.094)	0.221***	(0.026)	-0.286***	(0.094)	0.222***	(0.027)
Non-Russian	-0.258***	(0.093)	0.016	(0.025)	-0.257***	(0.094)	0.017	(0.025)
PGT	-0.069	(0.136)	0.099	(0.067)	-0.062	(0.140)	0.079	(0.061)
Rural	0.061	(0.085)	0.047	(0.039)	0.062	(0.084)	0.042	(0.037)
Unemployed	-0.547***	(0.068)	-0.106***	(0.017)	-0.549***	(0.068)	-0.106***	(0.017)
Secondary education	-0.135	(0.101)	-0.024	(0.025)	-0.134	(0.102)	-0.027	(0.025)
University education or above	-0.626***	(0.107)	-0.137***	(0.029)	-0.627***	(0.107)	-0.137***	(0.029)
Vocational education	0.282***	(0.085)	-0.007	(0.025)	0.283***	(0.086)	-0.008	(0.025)
Believer	0.01	(0.103)	-0.085***	(0.030)	0.013	(0.103)	-0.084***	(0.030)
Non-believer	0.158	(0.125)	-0.058*	(0.033)	0.158	(0.125)	-0.055*	(0.032)
Married	0.217***	(0.056)	0.015	(0.014)	0.216***	(0.057)	0.015	(0.014)
(Intercept)	-0.796	(1.121)	0.37	(0.380)	-0.701	(1.188)	0.635*	(0.345)

that a woman was a smoker, 2011-2014. Finally, the coefficient of **WF** with respect to the consumption decision was 0.003, with a cluster-robust standard error of 0.002 (P=0.042). This provided moderate evidence that an increase of **WF** of 1% of GRP corresponds to a 0.003 increase in the log count of cigarettes smoked per day. To put this into context, someone that smokes would be expected to increase consumption by 0.31% for a 1% of GRP increase in WF, but by 21.26% for a 62.46% of GRP increase in FDI (See Section 5.4.1). At the modal consumption level of 10, a ceteris paribus 21.26% difference in **WF** would correspond to a 2.126 difference in the number of cigarettes per day smoked by females over 18 smokers across the range of **WF** in Russia, 2011-2014.

Table 5.4: *Hurdle regressions of FDI, **WF** and smoking in Russian Women, 2011-2014*

Model	**(5.3)**				**(5.4)**			
Part	**Binomial**		**Count**		**Binomial**		**Count**	
Exposure measure	**Regional FDI**				**Spatially weighted FDI (WF)**			
Value	β	**S.E.**	β	**S.E.**	β	**S.E.**	β	**S.E.**
Regional Covariates								
FDI (%GRP)	0.024***	(0.007)	0.001	(0.002)				
WF (%GRP)					0.019***	(0.004)	0.003**	(0.002)
ln(lagged GRP)	0.110*	(0.060)	-0.008	(0.017)	0.103	(0.063)	-0.013	(0.017)
ln(regional population)	-0.005	(0.129)	0.013	(0.022)	-0.056	(0.131)	-0.012	(0.023)
Cigarette prices (USD)	1.799***	(0.516)	0.09	(0.144)	1.549***	(0.514)	-0.028	(0.148)
Household Covariates								
Household size	0.041*	(0.023)	0.014	(0.010)	0.041*	(0.022)	0.015	(0.010)
2nd Asset Quintile	-0.024	(0.081)	-0.107**	(0.043)	-0.019	(0.082)	-0.106**	(0.043)
3rd Asset Quintile	-0.145	(0.100)	-0.065*	(0.036)	-0.136	(0.098)	-0.067*	(0.036)
4th Asset Quintile	-0.228**	(0.106)	-0.072	(0.046)	-0.224**	(0.105)	-0.075	(0.046)
5th Asset Quintile	-0.423***	(0.109)	-0.091*	(0.049)	-0.410***	(0.108)	-0.096*	(0.050)
Individual Covariates								
ln(age)	-1.233***	(0.084)	0.236***	(0.038)	-1.243***	(0.084)	0.238***	(0.038)
Non-Russian	-0.491***	(0.175)	-0.068	(0.059)	-0.484***	(0.174)	-0.066	(0.059)
PGT	-0.502**	(0.246)	0.066	(0.068)	-0.692***	(0.200)	0.024	(0.070)
Rural	-0.188	(0.130)	0.032	(0.044)	-0.233*	(0.130)	0.017	(0.043)
Unemployed	-0.625***	(0.099)	-0.066***	(0.024)	-0.613***	(0.099)	-0.069***	(0.024)
Secondary education	-0.216	(0.148)	-0.064	(0.046)	-0.219	(0.149)	-0.067	(0.045)
University education or above	-1.002***	(0.170)	-0.113**	(0.051)	-0.998***	(0.171)	-0.118**	(0.051)
Vocational education	-0.071	(0.120)	-0.071*	(0.042)	-0.066	(0.121)	-0.070*	(0.042)
Believer	-0.615***	(0.206)	-0.201***	(0.076)	-0.638***	(0.203)	-0.196***	(0.076)
Non-believer	-0.232	(0.214)	-0.139**	(0.056)	-0.237	(0.208)	-0.133**	(0.056)
Married	0.393***	(0.054)	0.046	(0.031)	0.399***	(0.055)	0.048	(0.031)
(Intercept)	0.839	(1.964)	0.002	(0.392)	1.824	(2.045)	0.472	(0.401)

5.5 Discussion

5.5.1 Principal findings

Hurdle models using simply regional FDI as a measure of exposure to FDI (Models 5.1 and 5.3) suggest that male smoking behaviour is not associated with regional levels of FDI, either in terms of the odds of being a smoker, or the quantity of cigarettes smoked amongst smokers. Conversely, when using this same model specification, regional FDI was found to be associated with higher odds of smoking amongst Russian women.

When taking the spatial diffusion of FDI across regions into account, using the strategy detailed in Section 4.2.2, associations were found in both the male and female RLMS samples. In males, an association between FDI exposure and the participation decision (See Sections 5.2.1 and 5.3) was not found. Yet, the count component of Model 5.2 provides moderate evidence to suggest a positive association between FDI exposure and increases in consumption among male smokers. The effect of FDI exposure, across its range in the 33 regions included in the estimation sample (3.02-65.48 %), on smoking consumption in 'typical' Russian male smokers (who smoke 20 cigarettes per day) was estimated to be approximately 3.947. This is a small effect, considering the large discrepancy in FDI inflows between regions included in the RLMS, and amongst those regions with more similar levels of FDI, the effect of FDI on cigarette consumption appear to be marginal. Nevertheless, these models indicate that Russian regions with higher FDI exposure have similar smoking prevalence amongst men, yet marginally higher cigarette consumption amongst male smokers.

In females, an association between FDI exposure and both the participation and consumption decisions was found. The results from Model 5.4 suggest 1% of GDP increases in WF to be associated with an odds-ratio of 1.019 for a female to also be a smoker. The effect of FDI exposure between 3.02% and 65.48% of GRP at the modal smoking level of 10 per day was estimated to be 2.126, meaning that a region at FDI exposure of 3.02% would be expected to have smokers who smoke 2.126 less cigarettes per day than a region at an exposure of 65.48% of GRP. As with males, this is a rather small effect, especially when considering that most of the regions included in the RLMS have FDI inflows closer to the mean level of 15.44% (See Appendix Table D.2). Russian regions at higher levels of exposure to FDI are estimated to have both more female smokers, and female smokers with higher levels of cigarette consumption, even after controlling for regional characteristics and other covariates.

One notable feature of the regression results is the positive coefficients for cigarette price in the participation decision, whether using FDI or WF as a measure of FDI exposure, despite controls for wealth and individual characteristics. Table 5.2 shows that over 75% of the sample of females who smoke were urban, and the coefficients for PGT or rural status in Table 5.4 suggest urban status to be associated with an increased propensity for a female to be a smoker. It may be the case, therefore, that the important association there is in fact between urban status and propensity for a woman to be a smoker, and that this leads to a positive correlation between price and smoking status. Alternatively, the positive associations in the participation (binomial) model portions of models 5.3 and 5.4, along with the very weak negative association in model 5.2 may reflect the price inelasticity of demand for tobacco, as suggested by Herzfeld *et al.* (2011, 2014). Suppliers have an incentive to increase prices in reaction to high demand, which will then fall less than proportionately to generate more profits (or in the case of females, even continue to increase). This may have also affected the correlation between price and propensity to be a smoker.

These findings provide quantitative support for the very few previous works exploring the association between FDI and smoking in LMICs. They also add a degree of robustness and some contribution to the level of inference which can be drawn from the results, due to the inclusion of control variables and calculation of robust standard errors. Models 5.1-5.4 suggest a positive association between FDI and smoking, supporting the correlation identified in the work by

Gilmore & McKee (2005) on smoking and FDI in former-Soviet Union countries.

5.5.2 Strengths and Limitations

The predominant strength of this chapter was the ability of the econometric method used to investigate both the decision to smoke, and the decision on how much to smoke simultaneously. The Poisson count design also allowed estimation of the non-linear association between changes in FDI exposure and smoking behaviours across different initial levels of FDI exposure. The association between a change in FDI exposure and cigarette consumption could be estimated for the 'average smoker' within the sample, after controlling for other covariates.

The sample was large and varied enough to stratify by sex, which permitted separate investigation for males and females. This was a strength of the study, as the differences in smoking behaviours between sexes in Russia are stark (See Figure 5.4), suggesting the possibility that the importance of socio-economic varied by sex. Stratified analysis confirmed this, indicating there to be a notable difference in the estimated association between FDI and smoking.

Another strength of this chapter is the approach to adjusting for the effect of FDI in one region on the contiguous regions. As in Chapter 4, this notably affected the estimated association between FDI and the health-related outcome considered. Future studies considering FDI and health within a single country should continue to incorporate a strategy to take this factor into account, or risk biased estimations due to measurement error. Nevertheless, the choice of spatial weighting based on the proximity of regional capital cities was simple, and can undoubtedly be developed further to better adjust for the potential for investment in one place to affect health in another.

These results are based on data the 2011-2014 period due to the unavailability of regional level FDI statistics prior to 2011. However, much of the growth in FDI inflows to Russia happened before this. Consequently, the study omitted the period in which the Russian economy changed the most, and it may therefore be the case that the analysis in Chapter 5 misses the period in which the respective changes in health behaviours were most most pronounced. Nevertheless, regression models using this time period provide evidence suggesting that this association persists to this day.

As discussed in Chapter 1 and Section 5.1, FDI may be affecting population health and health-determining behaviours through a number of channels, some of which change simultaneously to FDI. In Russia, the participation and consumption of cigarettes may be driven through advertising, marketing and increased levels of competition for cigarette demand immediately following FDI inflows, along with the mechanisms discussed in earlier chapters. Aggregate FDI to a region, or the surrounding regions is acting as a proxy for the amount of FDI which will subsequently affect prices, marketing and advertising of tobacco in the models within this chapter. Yet regional FDI data which is industry-specific (industry being defined as 'Food, beverages, and tobacco', See Table 3.1) would undoubtedly be a superior instrument to measure the level of influence which foreign entities are having on the Russian tobacco industry. When and if this information becomes available for researchers to use, it will become possible to conduct analyses which can identify and control for many more mediating factors, therefore enabling more precise identification of the association between FDI and smoking in Russia. Further, the extent to which the regression models can capture the specific mechanism driving the associations identified is limited.

The impact of FDI on smoking behaviours is likely to occur over time (as is also true of nutritional health implications, as discussed in Section 4.5.2). However, as FDI to Russian regions is only available annually for the 2010-2014 period, one quarter of the data would be lost by looking at a lagged association, and the time period over which the study was conducted is insufficient to examine any dynamic associations reliably. Consequently, the ability of the regression models to detect the association may be limited. Nevertheless, an association was found, suggesting FDI to be correlated with increasing participation and consumption of tobacco in Russia. When more repeated cross-sections of data become available, the scope for investigating the dynamic association, or the association over time, between FDI and smoking behaviours in Russia will increase.

The scope for cross country comparison using the findings in this chapter is limited, as the association found between FDI and smoking behaviours could be specific to Russia. Until different countries are used for similar case-studies, or a consolidated investigation is conducted, scope for assessing the generalizability of the associations found to LMICs in general are limited.

5.6 Conclusion

Regional FDI and FDI adjusting for its effects on close-by regions are both associated worsening smoking behaviours within the Russian adult population, even when considering a very recent sample and controlling for regional fixed-effects, time trends and a range of covariates. Taken literally, this supports the argument that FDI into LMICs harmfully affects health behaviours. Future work should consider FDI to potentially be a socio-economic determinant of other health behaviours in Russia, and perhaps in other LMICs as well.

CHAPTER 6

Discussion and Conclusions

6.1 Overview

There has thus far been a scarcity of quantitative research on the relationship between foreign direct investment (FDI) and population health in low and middle-income countries (LMICs). Consequently, the understanding of the shape and nature of this inter-relationship is limited. The goal of this thesis was to contribute to the evidence as to whether, and, if so, to what extent FDI is benefiting or harming population health in LMICs. Four studies were conducted, which when taken together lay down a foundation of evidence on the association between FDI and health in LMICs. The original aims of the thesis from Chapter 1 were:

1. To collect and consolidate current quantitative evidence on the association between all forms of trade and population health outcomes
2. To use this collected knowledge to develop a theoretical framework of the association between FDI and population health in LMICs
3. To explore whether an overall association between FDI and population health outcomes exists in LMICs, using econometric methods
4. To use the findings from the overall analysis to further investigate whether an association exists on a more micro-level, through utilising large-scale individual level data sources from LMICs
5. To bring the findings together, discuss the association between FDI and population health in LMICs, and reflect on the approaches taken

During the progression of the thesis, these aims became the following four research questions:

1. What was current quantitative evidence on the relationship between international trade, in all its forms, and population health?

2. What was the impact of FDI on health in the cross-country LMIC context?

3. What was the association between FDI and nutritional health outcomes in Chinese adults?

4. What was the association between FDI and smoking behaviours in Russian adults?

This final chapter has four sections. The first is a summary of the principal findings of each study, how they interact, and how the findings can be considered together. This is followed by a discussion of the research questions and their results within the context of the broader globalisation and population health literature. Third is a section focused on critically evaluating the methodological selection and execution within the thesis. Finally, suggestions for future research topics are made, along with some recommendations on methodological approaches and data sources as well as concluding comments.

6.2 Summary of Principal Findings

Chapter 2 was focused on collecting and critically evaluating the available quantitative evidence on international trade — including FDI — and non-nutritional health outcomes in LMICs. 16 studies were included in the review. These were identified to have a mixed level of study quality, and made a mixture of conclusions on whether trade, FDI or both have a beneficial or harmful overall impact on population health. The literature included in Chapter 2 was considered as one, and four messages were identified. These included:

1. The likelihood that FDI is a socio-economic determinant of population health, but a lack of evidence on whether it is a net-harmful or net-beneficial association

2. The possibility that the FDI and health association is bi-directional

3. The sensitivity of results to the sample of countries included in the analysis, particularly when the inclusion criteria is based on country income levels

4. The untapped potential of individual level datasets for exploration of the trade — or FDI — and health association

This suggested an association between FDI and population health, both on the aggregate and individual levels, highlighting the utility of investigating both. The primary conclusion of Chapter 2 was that international trade is generally beneficial to population health, and is particularly beneficial to populations in LMICs. A lack of quantitative research into the effect which FDI may having on population health (on both the aggregate and individual levels) in LMICs was also identified.

The aim of Chapter 3 was to quantitatively investigate FDI and health in LMICs on the aggregate level, whilst taking into account the likelihood that the association between them may run in both directions. The chapter focused on country level aggregate FDI and life expectancy in LMICs. Additionally, an investigation into the importance of industrial composition was incorporated following on from previous works by Jorgenson (2009a,b).

Chapter 3 used an instrumental variable (IV) approach for the primary analysis, in the form of information on the macroeconomic determinants of FDI outflows from the investing countries, an approach previously used in quantitative literature focused on remittances (Aggarwal *et al.*, 2011; Kyrkilis & Pantelidis, 2003; Yang & Martinez, 2006). IV was not possible for the secondary analysis, as it was not possible to trace, for instance, the outflow of FDI in manufacturing industries through to the inflow of manufacturing FDI to a recipient LMIC. Consequently, the sectoral analysis was more likely to be biased by endogneity.

The results from Chapter 3 suggested FDI inflows to LMICs were associated with increased life expectancy during the sample period, thereby suggesting a beneficial association between FDI and health. Statistical testing indicated the relevance and validity of the instruments used, which increased the extent to which causal inference could be drawn from the results. IV estimates provided no evidence of an association between FDI and infant or child mortality rates, yet provided strong evidence of a beneficial association with adult mortality. This was taken to imply the particular importance of FDI to overall adult health in LMICs, with the caveat that no association may have been found in infants or children, possibly due to the otherwise positive impact of FDI was being offset by other harmful effects like pollution (Jorgenson, 2009a,b). In the sectoral analysis, the fixed-effects model (Model 3.8) provided tentative evidence of population harm as a result of the proportion of total FDI made up from secondary (manufacturing) industry investments. Although this model was not as robust as the IV models, Model 3.8 was taken to suggest that factors other than the total quantity of FDI might matter for population health impact. This supported the work done by Moran (2004, 2005, 2011) on the developmental influences of FDI in LMICs, which has consistently suggested the importance of the industries which are receiving FDI.

Chapter 3 suggested that the overall association between FDI and health in LMICs may be a positive one. The chapter also questioned whether quantity of FDI flows to an LMIC is the only thing determining health implications, and also indicated a strong association between FDI and adult health. However, Chapter 3 did not take advantage of the many large-scale individual level household panel datasets available from LMICs, and did not provide any insight into the association between FDI and specific aspects of health.

Chapter 4 investigated FDI and nutritional health in China, specifically the association between regional levels of FDI inflow and individual BMI, using data from the China Health and Nutritional Survey (CHNS), 1993-2011 (Zhang *et al.*, 2014). As previous economics literature on the effects of FDI in china suggested that the economic impacts of FDI transcend administrative boundaries, a spatial adjustment was made to the FDI measure used (Blanc-Brude *et al.*, 2014; Blonigen *et al.*, 2007; Sharma *et al.*, 2014). In addition to this, literature surrounding nutritional health in China indicated differential impacts of socio-economic BMI determinants, depending on individual levels of BMI (Gordon-Larsen *et al.*, 2014; Shankar, 2010). As individual BMI may be more or less affected by FDI, dependant on that individual's level of BMI, Chapter 4 included quantile regressions, which estimate the effect of a change in a given explanatory variable on the conditional quantile (e.g. median), rather than on the conditional mean (as is done in ordinary least-squares regression).

Models using the adjusted FDI measure provided strong evidence of a positive association of small magnitude between FDI and BMI in Chinese adults. When exploring the differential impact of FDI, quantile regressions indicated no significant variation in the FDI coefficient at any quantile of BMI within the central 90% of individuals' BMI. This suggested that the association between FDI and individual BMI in Chinese adults did not vary by level of BMI during the 1993-2011 period, which in turn indicated that FDI is responsible for a uniform shift to the right of the entire BMI distribution in the Chinese adult population. The evidence provided in Chapter 4 therefore suggests a mixture of positive and negative health impacts, as the overweight become more overweight, whilst the underweight improve.

Chapter 5 focused on the association between regional FDI and smoking in Russian adults, taking a similar spatial approach to Chapter 4. Smoking is a health behaviour of particular interest in relation to FDI, as tobacco corporations are well known to utilise FDI as a mechanism for achieving market access to increase market share, and making more effective advertising (Gilmore & McKee, 2004a; Kozyreva *et al.*, 2016; Zhang *et al.*, 2014). Further, there are also publicly available large-scale individual longitudinal household data for Russia, and smoking is already known to be a serious public health concern (Gilmore & McKee, 2005; Perlman *et al.*, 2007; WHO, 2016).

Smoking behaviours in Russian men and women were found to be very different, leading to a stratified analysis. The data on smoking consumption are also heaped, leading to individual reported smoking consumption being rounded to the nearest five, and subsequently treated as count data. Finally, the decision to smoke and how much to smoke are subsequent, leading to a double-hurdle approach being used.

The results of Chapter 5 provided strong evidence that regional FDI, even without taking FDI to contiguous regions into account is a determinant of participation in smoking behaviours amongst

Russian women. When taking FDI in other regions into account, evidence was also provided to suggest that women under a higher level of FDI exposure smoke more cigarettes, although the magnitude of the effect was small. In Russian Men, no evidence of an association was provided by models using regional FDI. Conversely, when taking FDI to other regions into account, some evidence of marginally increased consumption amongst men under higher FDI exposure was found.

Overall, Chapter 2 identified that FDI is likely to be a socio-economic determinant of health in LMICs, yet also identified a lack of quantitative research, and clarity on the overall effect. Chapter 3 addressed the overall case, suggesting that FDI is, in general, a force for good when looking through a cross-country overall health lens. Chapter 4 was more focused on nutritional health outcomes, suggesting a mixed effect, due to upward shifts of the entire population BMI distribution in Chinese adults. Finally, Chapter 5 investigated the smoking-related impacts of FDI, providing evidence to suggest that FDI is associated with increased participation in, and also marginally increased consumption of cigarettes. Taken as a whole, and as initially suggested in Chapter 2, the influence of FDI on health in LMICs has been shown in this thesis to be a mixture of beneficial and harmful effects. The overall benefit from FDI (as measured by the effect on life expectancy and on adult mortality) currently appears to outweigh the harm, yet with increasing BMI and engagement in damaging health behaviours resulting from FDI, there may come a point at which FDI is net-harmful to population health in LMICs.

6.3 Implications and Context of the Evidence Presented

The evidence presented in Chapters 2 and 3 suggests that the overall effect of FDI on health in LMICs may be a positive one. However, when looking more closely at the association in individual people in Chapters 4 and 5, and in different LMICs, harmful effects become apparent in the form of worsening health behaviours, and increasing BMI across whole populations. When taking these results at face-value, the indication is that the effect is a net-beneficial one, but harmful effects are very apparent within this. Yet, examining the evidence more closely, and contextualising the findings within the globalisation and health literature raises some important questions surrounding the meaning of the results, and of the research questions themselves.

6.3.1 The lack of data on FDI inflows to LMICs by industry or sector is hampering research

Chapter 3 utilised the most comprehensive national level FDI data covering LMICs which was also disaggregated by industry and/or sector, and is also publicly available (UNCTAD, 2003, 2004, 2008). The most recent data points were for 2008, many editions of the World Investment Directory (WID) were only available in print (or were out of print entirely), leaving a sample of approximately 30 LMICs to be included in the analysis. Industrially disaggregated outflows from one country were not traceable to their destinations, and disaggregated inflows were not traceable to their origins. This prevented the use of the instrumental strategy in Chapter 3 for the industrially disaggregated part, thereby limiting the utility of the dataset in the context of the thesis. It also prevented further investigation into the association between FDI and nutritional health, or health behaviours in the cross-country context.

In Chapter 4 and 5 respectively, associations between FDI and nutritional health or smoking could still be identified when using total FDI, which is testament to the likely importance of the association between FDI in the food, tobacco and beverages sectors and health in LMICs. Yet, it was not possible with current data to reliably investigate links between industrially disaggregated FDI inflows and aspects of individual health like nutritional health or smoking. These would be interesting analyses, which may shed additional light on the mechanisms involved.

A first step towards addressing this issue would be more systematic and comprehensive collection of data on FDI to LMICs. This may be difficult to achieve in some countries, due to issues with reporting, record keeping and international relations. Such data would enable researchers to establish to what extent FDI in different industries is accountable for worsening health behaviours, and nutritional health, which in turn can allow policy makers to restrict certain investments whilst encouraging others to improve population health.

6.3.2 FDI geography is an important consideration when investigating its health implications

Chapters 4 and 5 introduced some evidence that the regional distribution and concentration of FDI may influence the effect which FDI has on population health, despite China and Russia having very different geographical FDI distributions. Consequently, in future quantitative country case-studies of regional FDI and health, FDI in the surrounding regions be incorporated into the measure in some form.

6.3.3 Increasing BMI as a result of FDI is not entirely a bad thing

In Chapter 4 , regional FDI to China was found to be associated with an increased level of BMI amongst the adult population. Further investigation using quantile regression methods provided evidence to suggest that these BMI increases are similar across people at different levels of BMI. This includes underweight individuals (those with BMI ≤ 18.5). The proportion of overweight individuals in the CNHS sample is larger than the proportion of underweight individuals, suggesting that the overall impact is a negative one. However, there may be a small part of the population which are actually benefiting from FDI.

6.4 Strengths and Limitations

The strengths and limitations for Chapters 2-5 are evaluated within those chapters. However, when the thesis is considered together, there are also some common themes that need to be discussed.

One strength of the thesis is that a systematic review was used to establish the state and quality of current evidence on international trade in all its forms — not just FDI — in association with overall health outcomes. This cast a wide net for the range of health determinants discussed, whilst keeping the discussion focused on health outcomes like disease prevalence and mortality. The four messages extracted from this literature were valuable for steering the subsequent analyses in the thesis. In particular, the idea that FDI may determine, as well as be determined by, population health in LMICs, and the underutilisation of individual level datasets were particularly important in directing the subsequent research chapters. However, this systematic review also had limitations, which may have impacted certain elements of the thesis. Although the conclusions drawn from Chapter 2 were useful in forming the research questions on which subsequent chapters were based, the narrowing of the scope to international trade meant that additional research and reading outside of the systematic review was required to contextualise the findings. Further, the research questions formed following Chapter 2 may have been different had the systematic review had a broader scope. Yet, as discussed in Section 1.2, to conduct such a review is beyond scope of a PhD project. Overall, the systematic review was a useful exercise, but must be viewed in the context of these limitations.

This thesis took a number of different approaches to understanding the relationship between FDI and population health in LMICs. Chapter 2 included the *ex-ante* construction of a quality assessment framework, which was applicable to the particular range of studies considered. The sources and methods incorporated into this were from various organisations dedicated to systematic literature review, yet some flexibility was required to apply any combination of these into the trade and health context. The IV strategy in Chapter 3 used literature from other areas of economics when selecting appropriate instrumentation, which then led to more robust results. Chapters 4 and 5 took into account previous literature on the importance of FDI geography to its effect when devising an appropriate measure of FDI exposure. They also took advantage of available information from large-scale household surveys, combining this with the best available information on FDI. Finally, in Chapter 5, the meaning and interpretability of model results was considered when devising the appropriate econometric strategy.

To the extent that data would allow, Chapters 3-5 included extensive controls, which have been suggested by previous research into similar topics. This improved the extent to which any causal inference on the results could be made. Further, models which account for correlation between repeated measures were always used. This reduces concerns of heterogeneity bias in the estimations. Finally, where the possibility of a dynamic association between a control variable and the outcome of interest was identified (e.g. incomes and population health outcomes), lags of the control variable were used. This reduces the extent to which autocorrelation may have influenced the results.

Chapters 4 and 5 were focused on the health-related impacts of FDI. Yet, there is already a body of quantitative evidence to suggest that health forms part of human capital, leading to an association with subsequent inflows of FDI to LMICs (Alsan *et al.*, 2006; Desbordes & Azémar, 2009; Ghosh & Renna, 2015). This might imply some endogeneity bias in the country case studies. However, no evidence to date has investigated associations within countries, or when taking geographical biases into account (other than proximity to the equator, which was used as an instrument for health by Ghosh & Renna (2015)).

In this thesis, it was not possible to thoroughly explore the association between FDI in specific industries and subsequent health outcomes in LMICs, due to data limitations. This is a weakness, as when exploring the influence of FDI on nutritional health outcomes or adverse health behaviours, investigation into the specific industries like food, beverages and tobacco, or even the whole tertiary sector may well have led to a more rounded analysis. Although the evidence provided in Chapter 3 implicating population harms associated with secondary sector FDI into LMICs is not robust to endogeneity, it does highlight the potential for further exploration of the issue, data permitting.

The quantity of literature in the field of globalisation and health is large, and it is outside the scope of an individual PhD thesis to consider it all when forming a strategy of investigation. Further, not all of this literature is directly relevant to investigating the idea that FDI is leading to changes in population health in LMICs. Nevertheless, this literature, as discussed in Section 1.1.4, can be used to refine the research questions developed following Chapter 2. For instance, taking into account the social influences of globalisation alongside the economic ones could have helped to develop studies that may have been able to better isolate the association between FDI and health in LMICs.

Due to the aggregated nature of the data used in previous quantitative literature (See Chapter 2, and Table A.4), and in Chapter 3, the findings may to some extent be susceptible to aggregation bias. Trends which appear on the population level, may not translate to the association on the individual level (Piantadosi *et al.*, 1988). Further, in Chapters 4 and 5, which focused on the individual level association, the evidence presented did not suggest a beneficial association between FDI and health. The thesis includes some discussion of the mechanisms by which FDI may be affecting population health on the aggregate level which do imply an overall positive effect (at least with respect to the economic effects of FDI, and subsequent overall health impacts). These are supported by previous studies (See Sections 1.1.3, 2.4.2, and also Sections 4.5.1, and 5.1). For instance, the income effect suggested by Feenstra & Hanson (1997) may be benefiting overall measures of health, particularly in adults, more than the negative effects identified in Chapters 4 and 5 (See also: Hosseinpoor *et al.* (2011)), yet to formally test this is outside of the scope of the thesis.

Finally, China and Russia were used as case studies to explore the effects which FDI may have on nutritional health and adverse health behaviours, respectively. These countries have arguably had different experiences with FDI, and are also (mostly) geographically distant. However, it may be the case that the conclusions drawn in Chapters 4 and 5 cannot be extrapolated to LMICs generally. Recently, there have been some studies exploring socio-economic health determinants using large-scale household survey data which has been consolidated across a range of LMICs (Goryakin & Suhrcke, 2014; Goryakin *et al.*, 2015; Hosseinpoor *et al.*, 2011). Use of such a strategy in this context may lead to more generalisable findings.

6.5 Discussion of methodological approaches and data used

The thesis had a primarily quantitative approach. Although qualitative evidence was considered throughout, and this helped to steer the investigation, no qualitatively focused studies are included. However, given the scale of the research questions being addressed in Chapter 3, a qualitative would have been difficult to implement effectively. The later chapters provided some evidence that FDI may affect individual BMI or smoking behaviours, and these contexts do have some scope for investigation through a qualitative approach. However, this would still be a large undertaking, and the use of econometric methods in an attempt to identify a causal association between FDI and health in LMICs seemed to be the most feasible strategy within the scope of the thesis.

Overall, the structure of the thesis was adequate to establish research questions based on current evidence, and for subsequently investigating those questions. Yet, as discussed in Section 6.4, the extent to which Chapter 2 steered the subsequent research questions perhaps meant that the thesis did not investigate some other important avenues regarding the association between FDI and population health. Figure 6.1 illustrates the funnelling down structure of the thesis, and how the chapters link together.

Chapter 2 was a systematic review. However, the multidisciplinary nature of the international trade and health context led to the inclusion of articles with disparate research questions, spanning a broad range of academic domains, geographical contexts and methodological approaches. It also necessitated a very sensitive search strategy, leading to the initial inclusion of over 16,000 articles in the primary screening. Exchanging sensitivity for increased specificity may have saved time, yet the extent to which the resulting review would then represent the literature on trade and health would severely limit the contribution of the review itself.

No definitive guidelines for the systematic assessment of study risk of bias and/or quality exist which can be applied to the range of studies included in the review. Consequently, in order to assess each of the 16 included articles in a fair and balanced way, specific guidance was developed by bringing together the Cochrane risk of bias framework with the Campbell collaboration's guidance on assessing international panel studies. The resulting assessment framework was not strictly a risk of bias assessment, which is why language from the Cochrane risk of bias framework was avoided. The assessment framework was labour intensive and verbose in nature, and assessment of individual articles required the completion of a quality assessment sheet (See Appendices A.2, A.3, and A.5). A plus of the developed approach was that it allowed the reviewer to demonstrate understanding of each work, and to justify quality assessment allocation decisions.

The nature of the available data on FDI in LMICs controlled the extent to which the research questions laid out in Sections 1.2 and 6.1 could be addressed. In Chapter 3, investigating the association between FDI and population health on an international level using a cross-country analysis revealed an association, and with methods which were robust to a number of effects which could mask the 'true' association, but only provided limited insight into the mechanisms through which FDI ultimately affects health. Consequently, the inferences drawn from Chapter 3, along with (to a lesser extent) the later chapters were supported through additional literature searches focused on underlying mechanisms. Perhaps the inclusion of a study focusing on establishing the process of FDI affecting population health in LMICs would have been a useful addition to the thesis. Nevertheless, in Chapter 3, it was possible to gain some indication that the association was present in adults, and also perhaps in different industries, which then led to

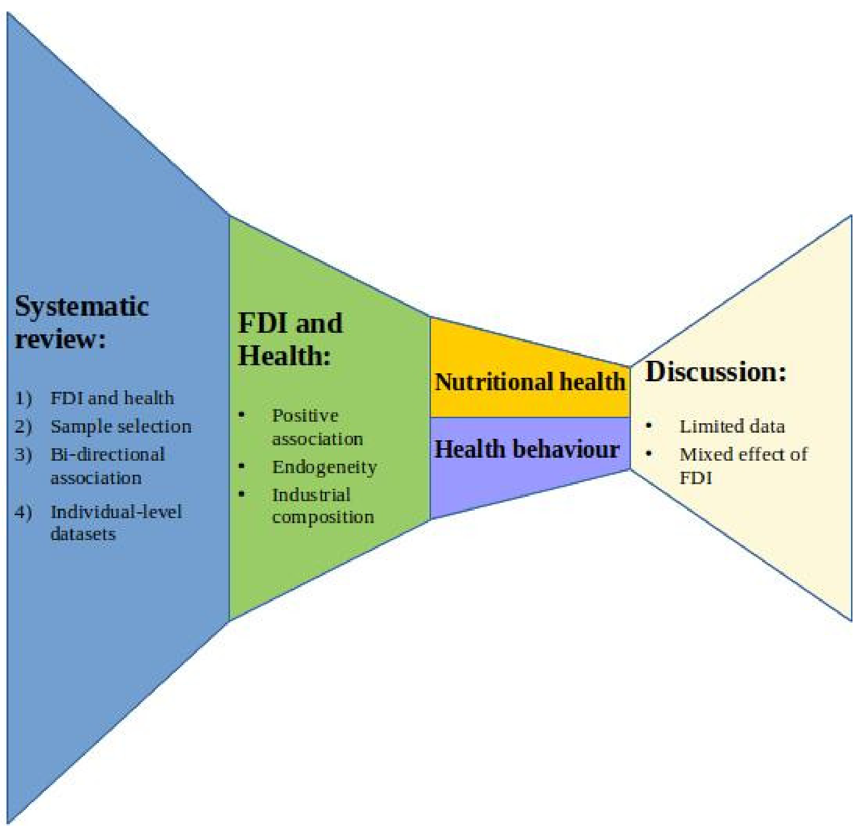


Figure 6.1: *Funnelling in design of the thesis*

the conceptualisation of the analyses in Chapters 4 and 5.

The data sources used in Chapters 4 and 5 were large and on an individual level, containing many descriptors which could be used to gain any number of insights into associations between economic exposures and health outcomes. Yet, due to the nature of available FDI data with a geographical identifier, the extent to which BMI and smoking behaviours could be linked with FDI was limited. For instance, the dynamic association could not be explored in Chapter 4, as the CHNS surveys were not conducted at regular intervals, and in Chapter 5, only four years of FDI data were available, limiting the utility of including lags of FDI exposure measures. In this capacity, perhaps other sources of data like the Global Adult Tobacco Survey, as used by Kostova *et al.* (2014), or Palipudi *et al.* (2014) could have been utilised to explore the associations in question from a different perspective. Nevertheless, some useful evidence was found when exploring the CHNS and RLMS datasets. This illustrates that using a smaller dataset is not always a limitation. For instance, were there to be a dataset specifically focused on marketing of tobacco products in Russia, and how that links to foreign direct investment, a whole different set of insights could potentially be drawn from this. However, developing such a dataset is a significant undertaking, requiring extentsive qualitative investigation, followed by data collection and ultimately quantitative investigation.

A major challenge, particularly in Chapters 3 and 5, was the selection of suitable methods. In Chapter 3 , the concern was primarily addressing the high likelihood that the association runs in both directions, as identified in Chapter 2, and as described in Figure 3.1 The process of selecting an appropriate instrument was lengthy, with a range of instrumentation ideas being rejected at either the theoretical level, during data collection or post-estimation testing stages. Ultimately, the appropriate choice was selected based on availability of data, and research into previous literature outside the scope of Chapter 2. For instance, bilateral trade agreements (BITs) were suggested as a factor which could explain FDI inflows to LMICs whilst remaining orthogonal from health outcomes. Investigating these potential instruments involved reviewing the BIT and FDI literature, manual collation of data on BIT membership and subsequent testing of the instrumental variable. BITs were rejected at the testing stage, due to their high correlation with health. With more research, it became apparent that many agreements facilitate the international trade of health technologies, leading to correlation with population health outcomes. As a number of avenues for valid instrumentation were pursued, development of the final IV strategy became increasingly inefficient. A separate study dedicated to finding appropriate instrumentation for FDI in the context of population health in LMICs would have likely been a more efficient and systematic means to identify appropriate instrumentation.

Chapters 4 and 5 , incorporated a spatial approach, in an attempt to accommodate the possibility that FDI to one region can affect the other surrounding regions. This utilised information on the straight-line distance between regional capitals. A more complex approach, perhaps adjusting for the nature of the terrain between different regions, could have potentially more precisely captured the spatial aspect of FDI effects on BMI or smoking. Regions which are separated by mountains are likely to interact less than those which are not, which may imply the importance of terrain to the spatial diffusion of FDI impacts on BMI or smoking. Nevertheless, this effect is likely to be a minor one, and the analyses in Chapters 4 and 5 consequently appropriately adjusted for inter-regional diffusion of FDI health impacts.

In Chapter 4, quantile regressions were used in an attempt to capture the differential impacts of FDI on individual BMI. These were adequate for identifying evidence surrounding the distributional effects of FDI on individual BMI, thereby satisfying the needs of the research question. However, it is feasible that a non-linear approach could be used to estimate a model with a higher level of predictive power, yet this would have had a much more complex interpretation, limiting the extent to which meaningful inference on FDI and individual BMI could be drawn.

In Chapter 5, the RLMS data on smoking participation and consumption had some features which complicated the appropriate analysis method. The proportion of zero-counts (i.e. non-smokers) was high in both males and females, and the responses were heaped. As both of these factors may cause bias in count data estimations, several approaches were considered. The first approach involved categorisation of individuals into non-smokers, light smokers, medium smokers and heavy smokers. A multinomial ordered logistic model was used to examine the association between regional FDI exposure and smoking category. However, this model was found to violate the proportional odds assumption via Brant test, implicating a lack of consistency in the estimated model (Cameron & Trivedi, 2005; Cameron & Trivedi, 2009). In this instance, one common approach is to then use a standard multinomial logistic model. This strategy was not implemented, due to the convoluted nature of subsequent model interpretation, and the extent to which that limited the utility of the method. Generalised ordered logit models and alternative gamma parametrization models were subsequently considered, yet the results were also difficult to interpret in any meaningful way. Secondly, the data was treated as count data, with non-smokers being classed as smoking zero cigarettes per day. This was a useful approach, as the model interpretation of Poisson and ZINB models is intuitive, and useful for capturing the magnitude of an exposure's effect (Cameron & Trivedi, 2013). As the proportion of zero-counts was high in both males and females, a hurdle/zero-inflated negative binomial strategy was used. However, the data was notably heaped, possibly leading to biased estimates. As a compromise between these two approaches, therefore, the resolution of reported smoking consumption was reduced from individual numbers of cigarettes to bands of five, and the resulting data was treated as count data. This was likely to largely represent the RLMS data, as the clear majority of individuals provided a multiple of five as their reported cigarette consumption. By undertaking this strategy, the interpretability of the model coefficients was not diminished (the estimated effect is simply multiplied by five), and the investigation could simultaneously investigate the decisions on smoking participation and consumption levels.

6.6 Suggestions for Future Research

This thesis did not completely explore the extent to which FDI may be affecting population health in LMICs. However, the thesis does lay down a foundation of evidence and investigation, on which future research can be built. The works included in this thesis, along with other evidence have gone some way to identifying what the overall association between FDI and health in LMICs — and its nuances — may be.

The overall effect of FDI was found to be beneficial in Chapter 3, with some possible caveats when considering FDI in specific industries. When looking at individual level longitudinal health data from China and Russia, more possibly harmful associations were found in the form of increasing BMI and participation in smoking behaviours as a result of FDI. Yet, the policies that this information can be used to inform, along with the extent of the public health concern which should be directed towards increasing FDI into LMICs was not a focal point of the thesis. One recommended area for future research is therefore on policy surrounding FDI in LMICs, from the population health perspective.

As mentioned in Section 6.4, some recent investigations have consolidated longitudinal health data from a number of LMICs, with the aim of drawing more generalisable conclusions on socio-economic determinants of health or health behaviours (Goryakin & Suhrcke, 2014; Goryakin *et al.*, 2015; Hosseinpoor *et al.*, 2011). Yet, Chapters 4 and 5 were focused on individual LMICs, limiting their generalisability. A consolidated study would be valuable in terms of establishing the influence of FDI on individual health in LMICs more generally, and is therefore a recommended future research topic. However, some aspects of this would likely be a challenge. These potential challenges include appropriate spatial adjustment for regional/national FDI, the role of trade agreements between countries, and the availability of regional FDI data from some LMICs.

There are already recent studies investigating the links between trade agreements or policies and population health, particularly in the context of nutritional health (Friel *et al.*, 2013; Hawkes *et al.*, 2009; Walls L; Friel *et al.*, 2013). Yet, only very few studies have focused on the specific role of FDI, a common means through which multi-national corporations achieve market access in LMICs (Hawkes, 2005). Other studies like Barlow *et al.* (2017) focus on trade and investment agreements, which can trigger a large set of parallel changes occurring at the same time as increases in FDI, all of which have their own implications for population health. One recommendation emerging from this thesis is therefore to build on previous research into the process through which FDI leads to changes in population health, perhaps applying quantitative methods to individual steps along the pathway from FDI to changing population health. This sequential approach may result in identifying important junctures at which policy interventions could be designed to reduce the negative consequences on health, whilst increasing any beneficial implications. However, this can become particularly complex when taking into consideration trade agreements and 'platform' FDI, or FDI in one country to achieve market access in another. Within these complex networks of trade, the health implications of FDI entering one place can manifest somewhere else, as the intention (the distribution of goods, marketing, production efforts) of the investment could be in a different region, or even country from the origin. To a limited extent, this was explored and identified to be important in Chapters 4 and 5. However, only by being able to distinguish between vertical, horizontal and platform FDI, and also being able to trace back FDI to its 'original destination', can a more productive effort be made to link this specific type of FDI to effects on population health. Any work to disaggregate FDI data into different classifications based on intent would be very valuable, since it could inform international trade policy and limit the extent to which MNCs can take advantage of trade environments to the decrement of people's health behaviours.

Chapter 3 provided some preliminary evidence of the proportion of FDI made up from secondary sector investments and worsening population health. However, this investigation was limited by the availability of data. This prohibited further exploration of industrially disaggregated FDI and population health in LMICs, both within individual countries and in a cross-country context. Consequently a recommendation for further work would be the ongoing collection of available information on FDI by industry — or even sector — in LMICs. It must be noted, however, that the compatibility of such FDI data across different LMICs is potentially a concern (See the OECD (2008) benchmark definition of FDI, and UNCTAD (2003, 2004, 2008) World Investment Directories for more information). Nevertheless, such data would be useful for future research into the health and economic effects that FDI has on LMICs. Of course, a subsequent recommendation is then research on industrially disaggregated FDI data and population health in LMICs. For instance, just one investigation would be whether manufacturing FDI in some Chinese provinces known for having a very large secondary sectors (Guanxi or Yunnan provinces, for instance) is having a subsequent impact on different aspects of health (for instance respiratory health, BMI, alcohol, smoking), either in those provinces or contiguous areas.

Chapter 5 established a statistical link between regional levels of FDI in Russia and smoking behaviours. However, no study to date has explored the links between FDI and other health behaviours whilst utilising longitudinal health data. Hawkes' work on the links between FDI and consumption of unhealthy foods goes some way to exploring these links, yet preciously little is known yet about links between FDI and individual sedentary lifestyles, consumption of alcohol, drugs or other risky behaviours. Work to further explore the utility of large-scale longitudinal health data towards answering these questions will undoubtedly be a significant contribution to the FDI and health literature.

Chapters 4 and 5 drew from literature on the economic effects of FDI to take into account diffusion of effects between regions of individual countries (Blanc-Brude *et al.*, 2014; Sharma *et al.*, 2014). However, the original work establishing the spatial diffusion of FDI effects by Blonigen et al. was cross-country in nature (Blonigen *et al.*, 2007). When also considering the above points on the importance of trade agreements, a recommendation of the thesis would therefore be a study in a similar vein to Chapter 3, but also taking into account spatial proximity of LMICs, and membership to different trade networks.

6.7 Concluding Remarks

FDI has become a large part of the international economy as a whole, and is also a means through which multi-national corporations achieve widespread market access. This suggests its importance to the jobs which people have and goods which they consume, which may subsequently impact their health. Despite this, there is very little quantitative evidence to suggest a link between FDI and population health, particularly in low and middle-income countries. Consequently, this thesis was focused on understanding what the association may be in an overall context, and then in more specific settings.

The evidence in this thesis suggests that in a cross-country context, FDI has a beneficial effect on overall population health. However, this effect is only perceptible when considering the fact that in LMICs, population health is also a determinant of FDI. Instrumental variable regression analysis provided moderate evidence of a positive association between FDI and population life expectancy in 85 LMICs. When investigating age-specific mortality, no association between FDI and either infant or child mortality was found. Conversely, strong evidence of an association with adult mortality was identified. The relationship between the industrial breakdown of FDI and population health outcomes was explored in a cross-country context. This was limited due to poor data for LMICs, yet some preliminary evidence of harm to life expectancy in relation to increased secondary FDI was found.

When exploring the effect of FDI on individual BMI and smoking, mostly harmful effects were found. In China, regional FDI is associated with increasing BMI. Due to the relatively high proportion of underweight people in China, this is not entirely a negative implication. However, in Russia, regional FDI was found to increase smoking participation, and also increase consumption levels amongst women that smoke.

In conclusion, it is hoped this thesis, and the ensuing publications, contribute to current knowledge on the presence and magnitude of the association between FDI and population health in LMICs. There is still a large amount of work to be done to fully understand the association between FDI and health. Yet, so far the international effect on overall health seems positive, whilst the individual effect on BMI or smoking seems negative.

Bibliography

Aggarwal, R., Demirgüç-Kunt, A., Pería, M. S. M., & Pería, M. S. M.: Do remittances promote financial development?, *Journal of Development Economics*, 96(2), (2011), 255–264.

Ahmed, F. Z.: Remittances Deteriorate Governance, *Review of Economics and Statistics*, 95(4), (2013), 1166–1182.

Al-Rodhan, N. R., & Stoudmann, G.: Definitions of globalization: A comprehensive overview and a proposed definition, *Program on the Geopolitical Implications of Globalization and Transnational Security*, 6, (2006), 1–21.

Alam, M. S., Raza, S. A., Shahbaz, M., & Abbas, Q.: Accounting for Contribution of Trade Openness and Foreign Direct Investment in Life Expectancy: The Long-Run and Short-Run Analysis in Pakistan, *Social Indicators Research*, (pp. 1–16).

Alfaro, L.: Foreign direct investment and growth: Does the sector matter, *Harvard Business School*, 2003, (2003), 1–31.

Alsan, M., Bloom, D. E., & Canning, D.: The effect of population health on foreign direct investment inflows to low- and middle-income countries, *World Development*, 34, (2006), 613–630.

Angrist, J. D., & Pischke, J.-S.: *Mostly harmless econometrics: An empiricists companion*, Princeton university press, 2008.

Antrás, P., Desai, M. A., Foley, C. F., The, S., Journal, Q., Aug, N., & Foley, C. F.: Multinational firms, FDI flows, and imperfect capital markets, 124(3), (2015), 1171–1219.

Asiedu, E., Jin, Y., & Kalonda-Kanyama, I.: The Impact of HIV/AIDS on Foreign Direct Investment: Evidence from Sub-Saharan Africa, *Journal of African Trade2*, 2(1-2), (2015), 1–17.

Baird, S., Ferreira, F. H. G., Özler, B., & Woolcock, M.: Relative Effectiveness of Conditional and Unconditional Cash Transfers for Schooling Outcomes in Developing Countries: A Systematic Review, *Campbell Systematic Reviews*, (8).

Barlow, P., McKee, M., Basu, S., & Stuckler, D.: The health impact of trade and investment agreements: a quantitative systematic review and network co-citation analysis, *Globalization and Health*, 13(1).

Barro, R. J., & Lee, J. W.: A new data set of educational attainment in the world, 1950-2010, *Journal of Development Economics*, 104, (2013), 184–198.

Bénassy-Quéré, A., Coupet, M., & Mayer, T.: Institutional determinants of foreign direct investment, *World Economy*, 30(5), (2007), 764–782.

Berggren, N., & Jordahl, H.: Does free trade really reduce growth? Further testing using the economic freedom index, *Public Choice*, 122, (2005), 99–114.

Bergh, A., & Nilsson, T.: Good for living? On the relationship between globalization and life expectancy, *World Development*, 38(9), (2010), 1191–1203.

Bettcher, D., & Lee, K.: Globalisation and public health, *Journal of Epidemiology & Community Health*, 56(1), (2002), 8–17.

Blanc-Brude, F., Cookson, G., Piesse, J., & Strange, R.: The FDI location decision: Distance and the effects of spatial dependence, *International Business Review*, 23(4), (2014), 797–810.

Blanchard, O.: *Macroeconomics*, Upper Saddle River, N.J.: Pearson Prentice Hall, 4th edn., 2006a.

Blanchard, O.: *Macroeconomics*, Upper Saddle River, N.J.: Pearson Prentice Hall, fourth edn., 2006b.

Blomström, M., & Sjöholm, F.: Technology transfer and spillovers: does local participation with multinationals matter?, *European economic review*, 43(4), (1999), 915–923.

Blonigen, B. A., Davies, R. B., Waddell, G. R., & Naughton, H. T.: FDI in space: Spatial autoregressive relationships in foreign direct investment, *European Economic Review*, 51(5), (2007), 1303–1325.

Blouin, C., Chopra, M., & van der Hoeven, R.: Trade and social determinants of health., *Lancet*, 373, (2009), 502–507.

Blouin, C., Drager, N., & Smith, R.: *International trade in health services and the GATS: current issues and debates*, World Bank Publications, 2006.

Bordo, M. D., Taylor, A. M., & Williamson, J. G.: *Globalization in historical perspective*, University of Chicago Press, 2007.

Borensztein, E., De Gregorio, J., & Lee, J.-W.: How does foreign direct investment affect economic growth?, *Journal of International Economics*, 45, (1998), 115–135.

Bozorgmehr, K., & San Sebastian, M.: Trade liberalization and tuberculosis incidence: a longitudinal multi-level analysis in 22 high burden countries between 1990 and 2010., *Health policy and planning*, 29, (2014), 328–51.

Bradshaw, M. J.: The Geography of Foreign Investment in Russia, 1993-1 995, *Tijdschrift voor Economische a Sociale Geografie*, 88(1), (1997), 77–84.

Bradshaw, M. J.: The changing geography of foreign investment in the Russian federation, *Russian Economic Trends*, 11(1), (2002), 33–41.

Busse, M., Königer, J., & Nunnenkamp, P.: FDI promotion through bilateral investment treaties: More than a bit?, *Review of World Economics*, 146(1), (2010), 147–177.

Cameron, & Trivedi, P. K.: *Microeconometrics using stata*, vol. 5, Stata press College Station, TX, 2009.

Cameron, A. C.: Microeconometrics: Current methods and some recent developments, in *Palgrave handbook of econometrics*, (pp. 729–774), Springer, 2009.

Cameron, A. C., & Trivedi, P. K.: *Microeconometrics: methods and applications*, Cambridge university press, 2005.

Cameron, A. C., & Trivedi, P. K.: *Regression analysis of count data*, vol. 53, Cambridge university press, 2013.

Central Bank of Russia: National and Regional Statistics, 2016a.

Central Bank of Russia: National and Regional Statistics, 2016b.

Chow, G.: Are Chinese official statistics reliable?, *CESifo Economic Studies*, 52(2), (2006), 396–414.

Cochrane Book Series: *Cochrane Handbook for Systematic Reviews of Interventions*, vol. Version 5., 2008, dOI: 10.1002/9780470712184.

Collaboration, C.: *Campbell Collaboration Methods Policy Brief*, 2013.

Collier, P., Dollar, D., & Bank, W. (Eds.): *Globalization, growth, and poverty: building an inclusive world economy*, A World Bank policy research report, Washington, DC : New York, N.Y: World Bank ; Oxford University Press, 2002, oCLC: ocm48626240.

Conde, W. L., & Monteiro, C. A.: Nutrition transition and double burden of undernutrition and excess of weight in Brazil, *The American journal of clinical nutrition*, 100(6), (2014), 1617S–1622S.

Coughlin, C. C., & Segev, E.: Foreign direct investment in China: A spatial econometric study., *World Economy*, 23(1), (2000), 1.

Craig, P., Cooper, C., Gunnell, D., Haw, S., Lawson, K., Macintyre, S., Ogilvie, D., Petticrew, M., Reeves, B., Sutton, M., & others: Using natural experiments to evaluate population health interventions: new Medical Research Council guidance, *Journal of epidemiology and community health*, (pp. jech–2011).

Cross, P., Edwards, R. T., Nyeko, P., & Edwards-Jones, G.: The potential impact on farmer health of enhanced export horticultural trade between the U.K. and Uganda., *International journal of environmental research and public health*, 6(5), (2009a), 1539–1556.

Cross, P., Edwards, R. T., Opondo, M., Nyeko, P., & Edwards-Jones, G.: Does farm worker health vary between localised and globalised food supply systems?, *Environment International*, 35(7), (2009b), 1004–1014.

Daude, C., & Stein, E.: The quality of institutions and foreign direct investment, *Economics and Politics*, 19(3), (2007), 317–344.

De Vogli, R.: Neoliberal globalisation and health in a time of economic crisis, *Social Theory & Health*, 9(4), (2011), 311–325.

Deaton, A.: Health in an Age of Globalization, Tech. rep., National Bureau of Economic Research, 2004.

Desbordes, R., & Azémar, C.: Public governance, health and foreign direct investment in Sub-Saharan Africa, *SIRE*.

Doak, C., Adair, L., Bentley, M., Fengying, Z., & Popkin, B.: The underweight/overweight household: an exploration of household sociodemographic and dietary factors in China., *Public health nutrition*, 5, (2002), 215–221.

Du, S. F., Wang, H. J., Zhang, B., Zhai, F. Y., & Popkin, B. M.: China in the period of transition from scarcity and extensive undernutrition to emerging nutrition-related non-communicable diseases, 1949-1992: Changes in China's diet, 1949-92, *Obesity Reviews*, 15, (2014), 8–15.

Feenstra, R. C., & Hanson, G. H.: Foreign direct investment and relative wages: Evidence from Mexico's maquiladoras, *Journal of International Economics*, 42, (1997), 371–393.

Fidler, D. P., Drager, N., & Lee, K.: Managing the pursuit of health and wealth: the key challenges, *The Lancet*, 373(9660), (2009), 325–331.

Filmer, D., & Pritchett, L. H.: Estimating Wealth Effects Without Expenditure Data – or Tears : An Applicaiton to Educational Enrollments in States of India, *Demography*, 38(1), (2001), 115–132.

Frankel, J. A., & Romer, D.: Does trade cause growth?, *American economic review*, (pp. 379–399).

Freedom House: Freedom in the World 2015 – Discarding Democracy: Return to the Iron Fist, (pp. 1–32).

Friel, S., Hattersley, L., Snowdon, W., Thow, a.-M., Lobstein, T., Sanders, D., Barquera, S., Mohan, S., Hawkes, C., Kelly, B., Kumanyika, S., L'Abbe, M., Lee, a., Ma, J., Macmullan, J., Monteiro, C., Neal, B., Rayner, M., Sacks, G., Swinburn, B., Vandevijvere, S., Walker, C., Thow, a.-M., Lobstein, T., Sanders, D., Barquera, S., Mohan, S., Hawkes, C., Kelly, B., Kumanyika, S., L'Abbe, M., Lee, a., Ma, J., Macmullan, J., Monteiro, C., Neal, B., Rayner, M., Sacks, G., Swinburn, B., Vandevijvere, S., & Walker, C.: Monitoring the impacts of trade agreements on food environments., *Obesity reviews : an official journal of the International Association for the Study of Obesity*, 14 Suppl 1(November 2012), (2013), 120–134.

Gerring, J., & Thacker, S. C.: Do neoliberal economic policies kill or save lives?, *Business and Politics*, 10.

Ghosh, S., & Renna, F.: The Relationship Between Communicable Diseases and FDI Flows: An Empirical Investigation, *The World Economy*, 38(10), (2015), n/a–n/a.

Gilmore, A. B., Fooks, G., & McKee, M.: A review of the impacts of tobacco industry privatisation: Implications for policy., *Global public health*, 6(July), (2011), 621–642.

Gilmore, A. B., & McKee, M.: Moving East: how the transnational tobacco industry gained entry to the emerging markets of the former Soviet Union-part II: an overview of priorities and tactics used to establish a manufacturing presence, *Tob Control*, 13, (2004a), 151–160.

Gilmore, A. B., & McKee, M.: Tobacco and transition: an overview of industry investments, impact and influence in the former Soviet Union, *Tob Control*, 13(2), (2004b), 136–142.

Gilmore, A. B., & McKee, M.: Exploring the impact of foreign direct investment on tobacco consumption in the former Soviet Union, *Tobacco Control*, 14(1), (2005), 13–21.

Google Inc.: *Gmaps Pedometer*, 2015.

Google Inc.: Google Maps, 2017.

Gordon-Larsen, P., Wang, H., & Popkin, B. M.: Overweight dynamics in Chinese children and adults, *Obesity Reviews*, 15(S1), (2014), 37–48.

Goryakin, Y., Lobstein, T., James, W. P. T., & Suhrcke, M.: The impact of economic, political and social globalization on overweight and obesity in the 56 low and middle income countries, *Social Science & Medicine*, 133, (2015), 67–76.

Goryakin, Y., & Suhrcke, M.: Economic development, urbanization, technological change and overweight: What do we learn from 244 Demographic and Health Surveys?, *Economics & Human Biology*, 14, (2014), 109–127.

Greene, W. H.: *Econometric Analysis*, vol. 97, Prentice Hall, 2003, dOI: 10.1198/jasa.2002.s458.

Grossman, G. M., & Krueger, A. B.: Environmental impacts of a north american free trade agreement, Tech. rep., National Bureau of Economic Research, 1991.

Gujarati, D. N.: *Basic econometrics*, Tata McGraw-Hill Education, 2009.

Gujarati, D. N., & Porter, D. C.: Essentials of econometrics.

Gustafsson, N.-K. J., & Ramstedt, M. R.: Changes in alcohol-related harm in sweden after increasing alcohol import quotas and a danish tax decrease–an interrupted time-series analysis for 2000–2007, *International journal of epidemiology*, 40(2), (2010), 432–440.

Hansen, H., & Rand, J.: On the causal links between FDI and growth in developing countries, *The World Economy*, 29(1), (2006), 21–41.

Hawkes, C.: The role of foreign direct investment in the nutrition transition, *Public Health Nutrition*, 8(04), (2005), 357–365.

Hawkes, C.: Uneven dietary development: Linking the policies and processes of globalization with the nutrition transition, obesity and diet-related chronic diseases, *Globalization and Health*, 2(1), (2006), 4.

Hawkes, C., Blouin, C., Henson, S., Drager, N., & Dubé, L.: *Trade, food, diet and health: perspectives and policy options*, John Wiley & Sons, 2009.

Hawkes, C., & Thow, A. M.: Implications of the central america-dominican republic-free trade agreement for the nutrition transition in Central America, *Revista Panamericana de Salud Publica/Pan American Journal of Public Health*, 24(5), (2008), 345–360.

Hayashi, F.: Econometrics.

Herzfeld, T., Huffman, S., & Rizov, M.: The dynamics of food, alcohol and cigarette consumption in Russia during transition, *Economics and Human Biology*, 13(1), (2014), 128–143.

Herzfeld, T., Huffman, S. K., & Rizov, M.: The Dynamics of the Russian Lifestyle During Transition : Changes in Food , Alcohol and Cigarette Consumption, 13(April), (2011), 128–143.

Holmes, K. R., O'Driscoll, G. P., O'Grady, M. A., D.C.), H. F. W., & (Firm), W. S. J.: *2002 index of economic freedom*, Washington, D.C. New York, N.Y.: Heritage Foundation ; Wall Street Journal, 8th edn., 2002.

Hosseinpoor, A. R., Parker, L. A., Tursan d'Espaignet, E., & Chatterji, S.: Social determinants of smoking in low- and middle-income countries: Results from the world health survey, *PLoS ONE*, 6(5).

Hsiao, C., & Shen, Y.: Foreign Direct Investment and Economic Growth: The Importance of Institutions and Urbanization, *Economic development and Cultural change*, 51(4), (2003), 883–896.

Hu, F. B.: Globalization of diabetes: the role of diet, lifestyle, and genes, *Diabetes care*, 34(6), (2011), 1249–1257.

International Development Coordinating Group (IDCG) - Campbell Collaboration: International Development Coordinating Group: Protocol and review methods, (July), (2013), 1–15.

International Monetary Fund: *International Financial Statistics*, 2015.

Iwasaki, I., & Suganuma, K.: Regional Distribution of Foreign Direct Investment in Russia, *Post-Communist Economies*, 17(2), (2005), 153–172.

Iwasaki, I., & Suganuma, K.: Foreign direct investment and regional economic development in Russia: an econometric assessment, *Economic Change and Restructuring*, 48(3-4), (2015), 209–255.

Jackman, S., Tahk, A., Zeileis, A., Maimone, C., Fearon, J., & Jackman, M. S.: Package 'pscl'.

Ji, C. Y., & Cheng, T. O.: Prevalence and geographic distribution of childhood obesity in China in 2005, *International Journal of Cardiology*, 131(1), (2008), 1–8.

JI Cheng Ye, CHEN Tian Jiao, JI, C. Y., CHEN, T. J., on Obesity in China (WGOC, W. G., & Others: Empirical Changes in the Prevalence of Overweight and Obesity among Chinese Students from 1985 to 2010 and Corresponding Preventive Strategies, *Biomedical and environmental sciences : BES*, 26(1), (2013), 23–31.

Jones, A. M.: A double-hurdle model of cigarette consumption, *Journal of applied econometrics*, 4(1), (1989), 23–39.

Jones, A. M.: Health econometrics, *Handbook of health economics*, 1, (2000), 265–344.

Jones, A. M.: *Applied econometrics for health economists: a practical guide*, Radcliffe publishing, 2007.

Jordaan, J. a.: Determinants of FDI-induced externalities: New empirical evidence for Mexican manufacturing industries, *World Development*, 33(12), (2005), 2103–2118.

Jorgenson, A. K.: Foreign Direct Investment and the Environment, the Mitigating Influence of Institutional and Civil Society Factors, and Relationships Between Industrial Pollution and Human Health A Panel Study of Less-Developed Countries, *Organization & Environment*, 22(2), (2009a), 135–157.

Jorgenson, A. K.: Political-Economic Integration, Industrial Pollution and Human Health: A Panel Study of Less–Developed Countries, 1980 –2000, *International Sociology*, 24(1), (2009b), 115–143.

Kawachi, I.: Globalization and workers' health, *Ind Health*, 46(5), (2008), 421–423.

Kleiber, C., & Zeileis, A.: *Applied econometrics with R*, Springer Science & Business Media, 2008.

Kleibergen, F., & Paap, R.: Generalized reduced rank tests using the singular value decomposition, 133, (2006), 97–126.

Knoema: *Federal State Statistics Service of Russia Data*, 2016.

Koenker, R.: *Quantile regression*, 38, Cambridge university press, 2005.

Kostova, D., Tesche, J., Perucic, A. M., Yurekli, A., & Asma, S.: Exploring the relationship between cigarette prices and smoking among adults: A cross-country study of low-and middle-income nations, *Nicotine and Tobacco Research*, 16(SUPPLEMENT1), (2014), 10–16.

Kozyreva, P., Kosolapov, M., & Popkin, B. M.: Data Resource Profile: The Russia Longitudinal Monitoring Survey–Higher School of Economics (RLMS-HSE) Phase II: Monitoring the Economic and Health Situation in Russia, 1994-2013, *International Journal of Epidemiology*, (p. dyv357).

Krugman, P. R., Obstfeld, M., & Melitz, M. J.: *International economics : theory and policy.*, vol. New York, of *Pearson series in economics*, Harlow : Pearson Education Limited, c2015., 2015.

Kyrkilis, D., & Pantelidis, P.: Macroeconomic determinants of outward foreign direct investment, *International Journal of Social Economics*, 30(7), (2003), 827–836.

Labonté, R., Mohindra, K. S., & Lencucha, R.: Framing international trade and chronic disease, *Globalization and Health*, 7.

Lance, P. M., Akin, J. S., Dow, W. H., & Loh, C. P.: Is cigarette smoking in poorer nations highly sensitive to price? Evidence from Russia and China, *Journal of Health Economics*, 23(1), (2004), 173–189.

Lee, K., Sridhar, D., & Patel, M.: Bridging the divide: global governance of trade and health, *The Lancet*, 373(9661), (2009), 416–422.

Levine, D. I., & Rothman, D.: Does trade affect child health?, *Journal of Health Economics*, 25, (2006), 538–554.

Li, X., & Liu, X.: Foreign Direct Investment and economic growth: An increasingly endogenous relationship, *World Development*, 33(3), (2005), 393–407.

Lipsey, R. E.: Foreign Direct Investment and the Operations of Multinational Firms: Concepts, History, and Data, *Handbook of International Trade*, (pp. 285–319).

López, M. L., Herrero, P., Comas, A., Leijs, I., Cueto, A., Charlton, A., Markham, W., & De Vries, H.: Impact of cigarette advertising on smoking behaviour in Spanish adolescents as measured using recognition of billboard advertising, *The European Journal of Public Health*, 14(4), (2004), 428–432.

Marmot, M., Friel, S., Bell, R., Houweling, T. A., & Taylor, S.: Closing the gap in a generation: health equity through action on the social determinants of health, *The Lancet*, 372(9650), (2008), 1661–1669.

Martens, P., Akin, S.-M., Maud, H., & Mohsin, R.: Is globalization healthy: a statistical indicator analysis of the impacts of globalization on health., *Globalization and health*, 6, (2010), 16.

McKee, M., Bobak, M., Rose, R., Shkolnikov, V., Chenet, L., & Leon, D.: Patterns of smoking in Russia, *Tobacco control*, 7(1), (1998), 22–26.

Milanovic, B.: The two faces of globalization: against globalization as we know it, *World Development*, 31(4), (2003), 667–683.

Miller, T.: *Index of economic freedom.*, New York: Wall Street Journal, 2015, oCLC: 903424839.

Moore, S., Teixeira, A. C., & Shiell, A.: The health of nations in a global context: Trade, global stratification, and infant mortality rates, *Social Science and Medicine*, 63(1), (2006), 165–178.

Moran, T. H.: *foreign direct investment and development: the new policy Agenda for developing countries and Economies in Transition*, 1998.

Moran, T. H.: *Beyond Sweatshops: Foreign Direct Investment and Globalization in Developing Countries*, Brookings Institution Press, 2004.

Moran, T. H.: How Does FDI Affect Host Country Development? Using Industry Case Studies to Make Reliable Generalizations, *Does FDI promote development?*, (pp. 281–314).

Moran, T. H.: *Foreign Direct Investment and Development: Launching a Second Generation of Policy Research: Avoiding the Mistakes of the First, Reevaluating Policies for Developed and Developing Countries*, Peterson Institute, 2011.

National Bureau of statistics of China: *China Statistical Yearbook*, China Statistics Press, 2014.

Noorbakhsh, F., Paloni, A., & Youssef, A.: Human Capital and FDI In flows to Developing Countries : New Empirical Evidence, *World Development*, 29(9), (2001), 1593–1610.

Notzon, F. C.: Causes of Declining Life Expectancy in Russia, *Jama*, 279(10), (1998), 793.

Nunnekamp, P.: Determinants of FDI in Developing Countries: Has gloablization changed the rules of the game?, *Econstor*, (1122).

O'Donnell, O., & Doorslaer, E. V.: *Analyzing Health Equity Using Household Survey Data*, December 1980, World Bank Publications, 2008, dOI: 10.2471/BLT.08.052357.

OECD: *OECD Benchmark Definition of Foreign Direct Investment'*, 4th editio edn., 2008.

Oster, E.: Routes of infection: Exports and HIV incidence in sub-Saharan Africa, *Journal of the European Economic Association*, 10, (2012), 1025–1058.

Owen, A. L., & Wu, S.: Is Trade Good for Your Health?*, *Review of International Economics*, 15(4), (2007), 660–682.

Palipudi, K., Rizwan, S. A., Sinha, D. N., Andes, L. J., Amarchand, R., Krishnan, A., & Asma, S.: Prevalence and sociodemographic determinants of tobacco use in four countries of the World Health Organization: South-East Asia region: findings from the Global Adult Tobacco Survey., *Indian journal of cancer*, 51 Suppl 1, (2014), S24–32.

Parente, P. M. D. C., & Santos Silva, J.: Quantile regression with clustered data, *Journal of Econometric Methods*, 5(1), (2016), 1–15.

Pärna, K., Rahu, K., Fischer, K., Mussalo-Rauhamaa, H., Zhuravleva, I., Umbleja, T., & Rahu, M.: Smoking and associated factors among adolescents in Tallinn, Helsinki and Moscow: a multilevel analysis, *Scandinavian Journal of Public Health*, 31(5), (2003), 350–358.

Perlman, F., Bobak, M., Gilmore, A., & McKee, M.: Trends in the prevalence of smoking in Russia during the transition to a market economy., *Tobacco control*, 16(5), (2007), 299–305.

Piantadosi, S., Byar, D. P., & Green, S. B.: The ecological fallacy, *American journal of epidemiology*, 127(5), (1988), 893–904.

Pomerleau, J., Gilmore, A., McKee, M., Rose, R., & Haerpfer, C. W.: Determinants of smoking in eight countries of the former Soviet Union: results from the living conditions, lifestyles and health study, *Addiction*, 99(12), (2004), 1577–1585.

Preston, S. H.: Mortality, morbidity, and development., *Population Bulletin of the United Nations Economic Commission for Western Asia*, 15, (1978), 63.

R Core Team: *R: A Language and Environment for Statistical Computing*, Vienna, Austria: R Foundation for Statistical Computing, 2017.

Rosstat: *Russian Regions, Social and Economic Indicators*, Moscow, 2014.

Saffer, H., & Chaloupka, F.: The effect of tobacco advertising bans on tobacco consumption, *Journal of health economics*, 19(6), (2000), 1117–1137.

Schaffer, M. E.: xtivreg2: Stata module to perform extended IV/2sls, GMM and AC/HAC, LIML and k-class regression for panel data models, *Statistical Software Components*.

Schrecker, T., Labonté, R., & De Vogli, R.: Globalisation and health: the need for a global vision, *The Lancet*, 372(9650), (2008), 1670–1676.

Shankar, B.: Obesity in China: the differential impacts of covariates along the BMI distribution., *Obesity (Silver Spring, Md.)*, 18(8), (2010), 1660–6.

Sharma, S., Wang, M., & Wong, M. C. S.: FDI location and the relevance of spatial linkages: Evidence from provincial and industry FDI in China, *Review of International Economics*, 22(1), (2014), 86–104.

Shrimpton, R., & Rokx, C.: Double Burden of Malnutrition, *Available at http:/tulane. edu/publichealth/internut/upload/08-04. pdf. Accessed*, 12.

Smith, R. D.: Foreign direct investment and trade in health services: A review of the literature, *Social science & medicine*, 59(11), (2004), 2313–2323.

Smith, R. D., Chanda, R., & Tangcharoensathien, V.: Trade in health-related services., *Lancet*, 373(9663), (2009a), 593–601.

Smith, R. D., Correa, C., & Oh, C.: Trade, TRIPS, and pharmaceuticals, *The Lancet*, 373(9664), (2009b), 684–691.

Smith, R. D., Lee, K., & Drager, N.: Trade and health: an agenda for action, *The Lancet*, 373(9665), (2015), 768–773.

StataCorp, L. P.: *Stata 13*, StataCorp LP., College Station, Texas, United States. http://www. stata. com, 2013.

Stuckler, D., McKee, M., Ebrahim, S., & Basu, S.: Manufacturing epidemics: The role of global producers in increased consumption of unhealthy commodities including processed foods, alcohol, and tobacco, *PLoS Medicine*, 9(6), (2012), 10.

Subramanian, S. V., Belli, P., & Kawachi, I.: The macroeconomic determinants of health., *Annual review of public health*, 23(10), (2002), 287–302.

Swiss Institute of Technology (Ed.): *Konjunktur-Forschungsstelle (KOF) Index*, vol. 2014, 2014.

Tolentino, P. E.: Home country macroeconomic factors and outward FDI of China and India, *Journal of International Management*, 16(2), (2010), 102–120.

UNCTAD: *World investment directory. Vol. 7: Central and Eastern Europe 2003*, New York: United Nations, 2003.

UNCTAD: *World investment directory. Vol. 9 Pt. 2: Latin America and the Caribbean 2004*, Geneva: United Nations, 2004.

UNCTAD: *World investment directory. Vol 10: Africa 2008*, New York, NY: United Nations, 2008.

UNCTAD: Bilateral FDI statistics.

UNCTAD: *Bilateral FDI by country of origin 2001-2012*, 2015.

United Nations: *International Standard Industrial Classification of All Economic Activities (ISIC), Rev.4*, vol. 1, 2008.

Veenstra, G.: Social capital and health (plus wealth, income inequality and regional health governance)., *Social science & medicine*, 54(6), (2002), 849–868.

Vogli, R. D., Kouvonen, A., Elovainio, M., & Marmot, M.: Economic globalization, inequality and body mass index: a cross-national analysis of 127 countries, *Critical Public Health*, 24(1), (2014), 7–21.

Walls L; Friel, R. H. C., S; Smith, Walls L; Freil, R. H. C., S; Smith, & Walls L; Friel, R. H. C., S; Smith: *Systematic Review Protocol: A review of the impact of international food-related trade policy on nutrition and health*, vol. 2014, LCIRAH database: LCIRAH, 2013.

Wang, H., & Heitjan, D. F.: Modeling heaping in self reported cigarette counts, *Statistics in Medicine*, 27(19), (2008), 3789–3804.

Wang, J.: The economic impact of special economic zones: Evidence from chinese municipalities, *Journal of Development Economics*, 101, (2013), 133 – 147.

Wang, M., & Wong, M. C. S.: Foreign direct investment outflows and business-cycle fluctuations, *Review of International Economics*, 15(1), (2007), 146–163.

WHO: *Country Profiles: Russia*, 2016.

Wickham, H.: *ggplot2: Elegant Graphics for Data Analysis*, Springer-Verlag New York, 2009.

Wooldridge, J.: Advanced panel data methods, *introductory econometrics: a modern approach. Mason: South-Western Cengage Learning*, (p. 489).

Wooldridge, J. M.: *Econometric Analysis of Cross Section and Panel Data*, 2002, dOI: 10.1515/humr.2003.021.

World Bank: *Definition of Foreign Direct Investment*, 2014.

World Bank,: *Country and Lending Groups*, 2015a.

World Bank,: *World development indicators*, 2015b.

World Health Organization: Plague - fact sheet, 2017.

Yang, D., & Martinez, C. A.: Remittances and poverty in migrants' home areas: evidence from the Philippines, in *International Migration, Remittances and the Brain Drain*, January, (pp. 81–121), World Bank, 2006.

Ye, J. C., & Cheng, T. O.: Epidemic increase in overweight and obesity in Chinese children from 1985 to 2005, *International Journal of Cardiology*, 132(1), (2009), 1–10.

Yusuf, S., Reddy, S., Ounpuu, S., & Anand, S.: Global burden of cardiovascular diseases: part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization, *Circulation*, 104, (2001a), 2746–2753.

Yusuf, S., Reddy, S., Ounpuu, S., & Anand, S.: Global burden of cardiovascular diseases: Part II: variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies, *Circulation*, 104, (2001b), 2855–2864.

Zaridze, D., Brennan, P., Boreham, J., Boroda, A., Karpov, R., Lazarev, A., Konobeevskaya, I., Igitov, V., Terechova, T., Boffetta, P., & Peto, R.: Alcohol and cause-specific mortality in Russia: a retrospective case-control study of 48 557 adult deaths, *The Lancet*, 373(9682), (2009), 2201–2214.

Zeileis, A., Kleiber, C., & Jackman, S.: Regression models for count data in R, *Journal of statistical software*, 27(8), (2008), 1–25.

Zhang, B., Zhai, F. Y., Du, S. F., & Popkin, B. M.: The China Health and Nutrition Survey, 1989-2011, *Obesity Reviews*, 15(S1), (2014), 2–7.

Zhang, K. H.: What Explains China's Rising Urbanisation in the Reform Era ?, *Urban Studies*, 39(12), (2002), 2301–2315.

Zinkina, J., Korotayev, A., & Andreev, A. I.: Measuring globalization: existing methods and their implications for teaching Global Studies and forecasting, *Campus-Wide Information Systems*, 30, (2013), 321–339.

Appendix

APPENDIX A

Supplementary materials for Chapter 2

A.1 Search strategy

The search strategy consists of four 'sets' of search terms. Each set is connected with the other sets via AND, except set 4 which is AND NOT. The individual search terms within a set are connected with OR. All sets search in the title, abstract and keywords of papers.

Set 1 contains terms for trade

Set 2 contains terms for health outcomes

Set 3 contains terms conducive of a relationship

Set 4 connected to the others via AND NOT

The resulting search is as follows:

(SET 1) AND (SET 2) AND (SET 3) AND NOT (SET 4)

These results will then be limited by English language, and to either articles or reviews.

The search includes Titles, abstracts or keywords

A.1.1 Search terms used

1. trade polic*
2. trade agreement*
3. free trade agreement*
4. trade liberali*
5. trade quantit*
6. trade amount*
7. volume* of trad*
8. trade volum*
9. imports
10. importing
11. export*
12. globali*ation
13. cross border trad*
14. international trad*
15. foreign direct investment*
16. cross border investment*
17. foreign own*
18. horizontal investment*
19. Vertical investment*
20. farm subsid*
21. agricultural subsid*

Set 2

22. Tuberculosis
23. HIV
24. AIDS
25. disease*
26. typhoid

27. Paratyphoid fever*
28. lower respiratory infection*
29. upper respiratory infection
30. otitis media
31. meningitis
32. encephalitis
33. diphtheria
34. whooping cough
35. tetanus
36. measles
37. varicella
38. malaria
39. echinococcosis
40. dengue
41. Rabies
42. food-borne trematodiases
43. maternal complication*
44. pregnancy complica*
45. hypertensive disorder* of pregnan*
46. obstructed labour
47. abortion
48. maternal problem*
49. birth complication*
50. neonatal encephalopathy
51. birth asphyxia
52. birth trauma
53. birth sepsis
54. disorder* of the newborn baby
55. neonatal disorder*
56. hepatitis
57. leprosy

58. cancer*
59. melanoma
60. non-Hodgkin lymphoma
61. leuk*mia
62. neoplasm*
63. cardiomyopathy
64. myocarditis
65. atrial fibrillation
66. atrial flutter*
67. aortic aneurysm
68. endocarditis
69. COPD
70. pneumoconiosis
71. asthma
72. pulmonary sarcoidosis
73. cirrhosis
74. peptic ulcer*
75. gastritis
76. duodenitis
77. appendicitis
78. paralytic ileus
79. intestinal obstruction*
80. hernia*
81. vascular disorder*
82. pancreatitis
83. Alzheimer's
84. dementia
85. Parkinson's
86. epilepsy
87. multiple sclerosis
88. migraine*

89. tension?type headache*
90. neurological disorder*
91. schizophrenia
92. unipolar depressive disorder*
93. Bipolar affective disorder*
94. anxiety disorder*
95. development disorders*
96. behavioural disorder*
97. intellectual disability*
98. mental disorder*
99. behavioural disorder*
100. diabet*
101. glomerulonephritis
102. urinary
103. infertility
104. h*moglobinopath*
105. haemolytic an*mia*
106. endocrine disorder*
107. blood disorder*
108. immune disorder*
109. rheumatoid arthritis
110. osteoarthritis
111. low* back pain
112. neck pain
113. gout
114. musculoskeletal disorder*
115. congenital anomal*
116. neural tube defect*
117. congenital heart
118. oral disorder*
119. sudden infant death

120. road injury
121. transport injury
122. drowning
123. poisoning*
124. exposure to mechanical forces
125. adverse effect* of medical treatment
126. animal contact
127. unintentional injur*
128. Self?harm
129. interpersonal violence
130. health outcome*
131. health stat*
132. mortalit*
133. morbidit*
134. chronic disease*
135. life expectanc*
136. work* stress
137. work related stress
138. hypertension
139. stroke*
140. disability?adjusted life year*
141. quality?adjusted life year*
142. daly*
143. qaly*
144. industrial *cident*
145. industrial injur*

Set 3

146. externalit*
147. spillover* impact*

148. relation*
149. causal*
150. data analys*
151. statistical analy*
152. correlation*
153. data source*
154. trade statistic*
155. databas*
156. link*
157. trickle?down
158. secondary effect*
159. regression*
160. fixed effects
161. random effects
162. OLS

Set 4

163. export protein*
164. export of protein*
165. nuclear import*
166. import protein*
167. animal health
168. export* *bolite*
169. cancer cell*
170. HIV-1
171. RNA*
172. malaria protein*
173. import receptor*
174. immuni*ation
175. vaccine

176. import of nuclear
177. stress model
178. botany
179. engineering
180. stress-impared
181. biomass
182. iron export
183. exporting signal*
184. export of beta*
185. data export*
186. parasite exports
187. biomedical
188. import of infected individuals
189. import* passengers
190. mitochondrial import

A.1.2 Scopus search query

TITLE-ABS-KEY("trade polic*" OR "trade agreement*" OR "free trade agreement*" OR "trade liberali*" OR "trade quantit*" OR "trade amount*" OR "volume* of trad*" OR "trade volum*" OR "imports" OR "importing" OR "export*" OR "globali*ation" OR "cross border trad*" OR "international trad*" OR "foreign direct investment*" OR "cross border investment*" OR "foreign own*" OR "horizontal investment*" OR "Vertical investment*" OR "farm subsid*" OR "agricultural subsid*")

AND

TITLE-ABS-KEY("Tuberculosis" OR "HIV" OR "AIDS" OR "disease*" OR "typhoid" OR "Paratyphoid fever*" OR "lower respiratory infection*" OR "upper respiratory infection" OR "otitis media" OR "meningitis" OR "encephalitis" OR "diphtheria" OR "whooping cough" OR "tetanus" OR "measles" OR "varicella" OR "malaria" OR "echinococcosis" OR "dengue" OR "Rabies" OR "food-borne trematodiases" OR "maternal complication*" OR "pregnancy complica*" OR "hypertensive disorder* of pregnan*" OR "obstructed labour" OR "abortion" OR "maternal problem*" OR "birth complication*" OR "neonatal encephalopathy" OR "birth asphyxia" OR "birth trauma" OR "birth sepsis" OR "disorder* of the newborn baby" OR "neonatal disorder*" OR "hepatitis" OR "leprosy" OR "cancer*" OR "melanoma" OR "non-Hodgkin lymphoma" OR "leuk*mia" OR "neoplasm*" OR "cardiomyopathy" OR "myocarditis" OR "atrial fibrillation" OR "atrial flutter*" OR "aortic aneurysm" OR "endocarditis" OR "COPD" OR "pneumoconiosis" OR "asthma" OR "pulmonary sarcoidosis" OR "cirrhosis" OR "peptic ulcer*" OR "gastritis" OR "duodenitis" OR "appendicitis" OR "paralytic ileus" OR "intestinal obstruction*" OR "hernia*" OR "vascular disorder*" OR "pancreatitis" OR "Alzheimer's" OR "dementia" OR "Parkinson's" OR "epilepsy" OR "multiple sclerosis" OR "migraine*" OR "tension?type headache*" OR "neurological disorder*" OR "schizophrenia" OR "unipolar depressive disorder*" OR "Bipolar affective disorder*" OR "anxiety disorder*" OR "development disorders*" OR "behavioural disorder*" OR "intellectual disability*" OR "mental disorder*" OR "behavioural disorder*" OR "diabet*" OR "glomerulonephritis" OR "urinary" OR "infertility" OR "h*moglobinopath*" OR "haemolytic an*mia*" OR "endocrine disorder*" OR "blood disorder*" OR "immune disorder*" OR "rheumatoid arthritis" OR "osteoarthritis" OR "low* back pain" OR "neck pain" OR "gout" OR "musculoskeletal disorder*" OR "congenital anomal*" OR "neural tube defect*" OR "congenital heart" OR "oral disorder*" OR "sudden infant death" OR "road injury" OR "transport injury" OR "drowning" OR "poisoning*" OR "exposure to mechanical forces" OR "adverse effect* of medical treatment" OR "animal contact" OR "unintentional injur*" OR "Self?harm" OR "interpersonal violence" OR "health outcome*" OR "health stat*" OR "mortalit*" OR "morbidit*" OR "chronic disease*" OR "life expectanc*" OR "work* stress" OR "work related stress" OR "hypertension" OR "stroke*" OR "disability?adjusted life year*" OR "quality?adjusted life year*" OR "daly*" OR "qaly*" OR "industrial *cident*" OR "industrial injur*")

AND

TITLE-ABS-KEY("externalit*" or "spillover*" or "impact*" or "relation*" or "causal*" or "data analys*" or "statistical analy*" or "correlation*" or "data source*" or "trade statistic*" or "databas*" or "link*" or "trickle?down" or "secondary effect*" or "regression*" or "fixed effects" or "random effects" or "OLS")

AND NOT

TITLE-ABS-KEY("export protein*" OR "export of protein*" OR "nuclear import*" OR "import protein*" OR "animal health" OR "export* *bolite*" OR "cancer cell*" OR "HIV-1" OR "RNA*" OR "malaria protein*" OR "import receptor*" OR "immuni*ation" OR "vaccine" OR "import of nuclear" OR "stress model" OR "botany" OR "engineering" OR "stress-impared" OR "biomass" OR "iron export" OR "exporting signal*" OR "export of beta*" OR "data export*" OR "parasite exports" OR "biomedical" OR "import of infected individuals" OR "import* passengers" OR "mitochondrial import")

Table A.1: *Adapted quality assessment aid for Chapter 2*

Quality	Interpretation	Within a study	Across studies
High quality.	No detected issues, or issues unlikely to seriously alter the results.	High quality for all key domains.	Most information is from studies with high quality.
Medium quality.	Issues that raise some doubt about the internal validity of the study.	Medium quality for one or more key domains.	Most information is from studies at High or medium quality.
Low quality.	Issues detected seriously weaken confidence in the internal validity of results.	Low quality for one or more key domains.	The proportion of information from studies at low quality is sufficient to affect the interpretation of results.

Reference: Adapted from Cochrane handbook for systematic reviews table 8.7a. See `www.handbook.cochrane.org`

A.2 Quality Assessment Tool

A.2.1 Overall assessment of quality in and between studies

Use the below table to make a qualitative assessment of quality in both individual papers, and across the literature being reviewed. Use the details of each domain below to aid assignment of quality.

A.2.2 Domain 1: Quality of the data

This domain is concerned only with the quality of data used in each article, and how this can affect internal validity. Authors' approach to analysing the data is dealt with in the methodology domain. The following issues should be considered, and a judgement on the quality associated with data should be based primarily on them. Issues with the data not covered below should be described in detail in order to incorporate them into the review.

For secondary data:

- Does the study acknowledge and address missing data issues?
- Does the study address the representativeness of the data used?
- Does the study address issues or problems with the consistency of data collection, trustworthiness of the data or any other issues that could bias the secondary data?

  - An example: The authors control for armed conflict to account for the non-trade related effect on mortality rates. In that case, do they consider quality or even existence of data during periods of conflict?

- If some data used in the study was composed or calculated by authors for use in the study: Was this data calculated or composed in a reasonable way that is unlikely to affect research results?

  - An example: In a study using spatial statistics and country level data, are the calculated distances between countries based on the centre of each country or distance of capital cities? Is the choice between these important? Are the authors' choices on this likely to affect the results?

For primary data:

- If the data is on an individual level, was the sampling method random?

  - If the sampling was not random, is the sampling method likely to affect the results?

- If the data is on a group level (e.g. by workplace, family group, geographical location and so on), do the authors consider that behaviour within a cluster can be correlated with that cluster (i.e. clustering effects)

- Do the authors discuss the problems that their data collection method could create? Are the effects of unique events and measurement error discussed?

A.2.3 Domain 2: Quality of data approach and analysis method

This domain is concerned with threats to internal validity brought about by the approach to the data the authors take, the selection of applicable analysis methodology, and the implementation of that method. Due to the topic area of this review, methodology and data are not consistent throughout selected studies. Therefore, for each statistical analysis method that could reasonably be applied to the available data, information on typical methods of showing internal validity is provided below. Reviewers should select the headers that are relevant to the article under review. With consideration to this information, reviewers should make a judgement of data approach and analysis method quality. The use of multiple methodologies is not viewed as an indication of internal validity, unless they are used for sensitivity analysis or some form of robustness testing. Multiple methods should be treated as such by referring to the multiple relevant headers if they are not used to test robustness of primary findings.

This domain is concerned with threats to internal validity brought about by the approach to the data the authors take, the selection of applicable analysis methodology, and the implementation of that method. Due to the topic area of this review, methodology and data are not consistent throughout selected studies. Therefore, for each statistical analysis method that could reasonably be applied to the available data, information on typical methods of showing internal validity is provided below. Reviewers should select the headers that are relevant to the article under review. With consideration to this information, reviewers should make a judgement of data approach and analysis method quality. The use of multiple methodologies is not viewed as an indication of internal validity, unless they are used for sensitivity analysis or some form of robustness testing. Multiple methods should be treated as such by referring to the multiple relevant headers if they are not used to test robustness of primary findings.

Approach to data:

- Do the authors consider and address unobservable differences between clusters (countries, regions, individuals and so on)?
  - Example: Using dummy variables for clusters or selection of methods which take this issue into account (e.g. fixed or random effects models)

- If the authors consider unobservable heterogeneity to not be an issue, is this justified?
  - Example: By referencing other works which show the issue to be unimportant

- Do the authors control for confounders, not just variables considered in the hypothesis?
  - Example: use of a correlation table to indicate the relationships between variables that in all likelihood have a complex relationship with multiple factors.

Methodology

Below is a list of typical methods to internally validate analysis methodologies. Please consider these steps in judgement of quality.

Regression discontinuity designs:

- Are the participants blinded **or** not able to amend the control?
- Do the authors show that the difference in characteristics between the control and intervention groups is small?
- If the design is such that a point in time is the beginning of the treatment, (e.g. before and after a country joins a free trade agreement), is there data shortly before and after the treatment?
  - Example: There may be a quality if data from 5 years before and 5 years after the exposure is used, since the effect of the treatment could be very short term, and an exogenous factor entered the situation in the meantime.
- Do authors control for exogenous factors affecting the outcome through regression?

Instrumental models

- Are the instruments F significant (i.e. is F≥10 in the instrumental model)?
- If the instrumental model does not use the Heckman procedure – are the individual identifying instruments significant?
- If the research uses the Heckman procedure, are the identifiers reported and significant?
- Are at least 2 instruments used, and do authors report the results of over-identifying tests? (not always essential to score high quality)
- Do the authors conduct a qualitative assessment of the exogeneity of instruments? Is the instrument exogenously generated?
- Do the authors control for confounders, and are these controls likely to be affected by participation?

Ordinary Least Squares (including reformulations that do not fit into other headers) and MLE estimations (e.g. logit, probit)

- Are the Gauss-Markov assumptions satisfied? If not, is the violation likely to bias the results? Are issues with the assumptions addressed?
- Do authors control for confounders in their regressions?

- Do the authors use proxies to account for unobserved heterogeneity
  - Example: using dummy variable for country in a multinational analysis (i.e. as a substitute for using a fixed effects model)
- If the design is quasi-experimental, does participation affect the control group?
- If the design is quasi-experimental, are the distributions of covariates shown to be balanced across groups?

Fixed effects, random effects and difference in difference

- Do authors control for time variant characteristics?
- Do the authors test the robustness of their model? Is their method for doing this applicable to the data they use?
- Was a Hausman test used to test the relative internal validity of Fixed Vs Random effects models?
- If the design is quasi-experimental, are there low levels of attrition (<10% is acceptable for this review)

Matching estimators

- If the primary method is propensity score matching, is the 'caliper width', or propensity score matching range mentioned? Do you consider it narrow enough? (0.1 is usual)
- Are any individuals from one group are matched with large numbers from the other?

Hypothesis testing – (e.g. t-tests and non-parametric testing)

Note: If bivariate testing is used, please consider your answer for quality in the data. If testing is bivariate, the data used must be adjusted for confounders in some way.

- Is the distribution of covariates is demonstrated by authors?

- If t-tests are students', is evidence provided showing data is normally distributed provided? Otherwise, are non-parametric t-tests used?
- If the authors use ANOVA, are the relevant assumptions satisfied? If not, is the data transformed to satisfy them?

A.2.4 Domain 3: quality in presentation of results

This domain is concerned only with the quality of results shown to readers. Guidelines (see methods section of paper) advise that assessments should judge research based on results brought into the review, rather than in the original article. However, due to the nature of the topic, data synthesis is difficult and controversial. With that in mind, the best way to proceed with the currently available resources is to interpret results as they are presented in articles, but with respect to the review topic. For example, if a study is about the effect of globalisation on health outcomes, only the aspect relevant to the study (international trade Vs health outcomes) should be considered. If such a study does not present results with respect to trade Vs health despite passing inclusion criteria, then this is an issue regarding presentation of results. Primarily, this domain is aimed at detecting steering of attention to particular results and away from others. It is not always possible to detect presentation of results issues, therefore the reviewer should use her or his judgement.

- Is there any indication that any results were omitted from the study? If so, was this entirely due to space constraints or is there reason to believe that omissions were strategic?
- Are the results framed in such a way as to influence how they are perceived, their discussion or the conclusions based on them?

A.2.5 Domain 4: Quality from post estimation testing and analysis interpretation

This domain is concerned with testing of model robustness and other post estimation steps that are relevant to this literature. With certain methodologies such as propensity score matching, this is vital in indicating internal validity. However, there are some other issues that apply more generally. Therefore for this section, the reviewer should consider the relevant aspects, and make an informed decision on quality due to post estimation analysis and testing.

- Are all reported results considered in the inference and discussion of results?
  - Example: discussion of the confounders and exogenous effects included in the analysis.
- Is there anything else in the inference and discussion that could bias the authors' conclusion?
  - Example: citing a theoretical paper that has since been discredited to concur with their results.
  - Do you consider it a possibility that the authors have downplayed the role of a particular confounder, with statements such as "this is unlikely to affect our result". Do you agree with these statements if they are used?

Post estimation tests and further modelling

Propensity score matching

- If the matching is under 90% are various matching methodologies used to conduct sensitivity analysis?
- If the authors do conduct sensitivity analysis, does it show results to be insensitive to the matching methodology?
- Do authors use the Rosenbaum test for hidden bias? Are the results sensitive to hidden bias?

IV models with the Heckman approach

- Do the authors use the selectivity correction term? Is it significantly different from zero?

A.2.6 Domain 5: Other study quality issues

This domain is to capture any unique or a-typical issues in articles, and anything not covered in the other domains. If a significant amount of work is considered have a medium or low quality associated with this domain due to the same or similar issues, the tool will be revised to incorporate that issue. If no other issues are detected here, this should not influence your overall decision on the bias risk in the article. A full description of issues detected should be provided by the reviewer.

A.3 Quality Assessment Form

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

A.3.1 Domain 1: Quality from the data

A.3.2 Domain 2: Quality associated with data approach and analysis method

A.3.3 Domain 3: Quality in presentation of results

A.3.4 Domain 4: Quality from post estimation testing and analysis interpretation

A.3.5 Domain 5: Other study quality issues

A.4 Data Extraction Table

Table A.2: *Data Extraction Table for Chapter 2*

Lead Author and year	Study Aim	Study design	Statistical Analysis Method(s)	Exposures considered	Outcome measures	Confounders controlled for	Results
Alsan *et al.* (2006)	To determine links between human life expectancy and Foreign Direct Investment inflows	Analysis of observational panel data. Annual data, 74 countries 1980 - 2000.	Panel regression. Also stratified into both high income and med/low income analyses.	Life expectancy	Foreign Direct Investment inflows	Total population GDP per capita openness of economy Bureaucratic quality Corruption Education Telephones per 1000 persons Distance to major markets landlocked (dummy) Period 1990-2000 (dummy)	Full panel. +0.075 (SE 0.027) log of gross FDI inflows per 1 year increase in life expectancy. Low/Middle income panel. +0.091 (SE 0.035) log of gross FDI inflows per 1 year increase in life expectancy. High income panel. -0.07 (SE 0.124) log of gross FDI inflows per 1 year increase in life expectancy.
Bergh (2010)	To determine links between the KOF globalization index and life expectancy.	Analysis of observational panel data. Annual data, 121 countries 1970 - 2005	OLS and fixed effects panel estimation with panel-corrected standard errors Random effects model (used for sensitivity analysis only)	KOF globalization index	Male life expectancy Female life expectancy	Demographic structure Healthcare availability Water sanitation Education Nutrition GDP per capita Sensitivity analysis also conducted by varying regression method	An increase of 1 in Lagged economic globalization (KOF1) associated with 4.473 (SE 2.098) year increase in life expectancy in fixed effects model. Social globalization (KOF2) not significant in any model. Political globalization (KOF3) significantly negatively associated with life expectancy in most models.

Lead Author and year	Study Aim	Study design	Statistical Analysis Method(s)	Exposures considered	Outcome measures	Confounders controlled for	Results
Bozorgmehr (2014)	To determine links between five different measures of trade liberalization and TB incidence in countries with high TB prevalence.	Analysis of observational panel data. Annual data from 22 countries with high tuberculosis prevalence 1990-2010	Multi-level regression analysis Fixed effects regression Random effects regression	Trade openness The Economic Freedom of the World Index (4th dimension) KOF index of globalization (KOF1). World Trade Organization membership (dummy) Duration of WTO membership.	Tuberculosis incidence	Age dependency ratio (% working age) Armed conflict Case detection rate (%) National debt payments GINI index Human–Development Index IMF charges ($bn) 'Polity2' Population density population in urban settings of more than 1 million Time since 1990 Use of IMF credit WTO cohort	NULL model. No association between any trade liberalization and TB incidence. Adjusted model. Increase of 1 EFI4 point was associated with 10.4% (SE 4.4) decrease in TB incidence. KOF1 increase of 1 point associated with 1.3% (SE 0.6) reduction in TB incidence. WTO membership positively associated with TB incidence at 95% confidence in 6 out of 10 models

Lead Author and year	Study Aim	Study design	Statistical Analysis Method(s)	Exposures considered	Outcome measures	Confounders controlled for	Results
Cross *et al.* (2009)	To determine links between worker health and whether the farm produces exports for domestic consumption or foreign consumption	Analysis of primary data collected opportunistically for 4 different countries. UK (605) Spain (472) Kenya (893) Uganda (573).	t-tests for the difference in means. ANOVA if parametric assumptions satisfied Mann-Whitney non-parametric testing if parametric assumptions not satisfied	Farm location and whether the farm produced for export or for domestic production	4 health survey instruments: SF-36 EQ5D VAS SDHS	Stratified analysis based on age-group and regression analysis to indicate the role of income level. not used to adjust the data for the primary analysis	Health of export horticultural workers indicated to be significantly higher than domestic producers in the sample.
Cross *et al.* (2009)	To determine links between worker health and whether the farm produces exports for domestic consumption or foreign consumption	Analysis of primary data collected opportunistically for 2 countries. UK ("approximately 1250") Uganda (571)	t-tests for the difference in means. ANOVA if parametric assumptions satisfied Mann-Whitney non-parametric testing if parametric assumptions not satisfied. OLS was used to establish links between socioeconomic variables and SF-36 result.	Whether the farm was Ugandan and exporting to the UK or UK producing for domestic consumption.	4 health survey based health state measurements: SF-36, EQ5D, VAS and SDHS	Farms matched on crops produced. Regression model (UK): farm id, farm size, farming method, tasks/day, wages, age, gender, nationality, marital status, number of children. Regression model (Uganda): house type, recent malaria, distance to work, number of children, smoker, education, income, bicycle ownership, radio ownership, mobile phone ownership, job status and tasks per day	Ugandan exporting farm workers significantly better health state than UK workers producing for domestic consumption when comparing to the US population norm. Income, radio ownership, bicycle ownership, education, smoking and other control variables significantly linked to SF-36 results using OLS.

Lead Author and year	Study Aim	Study design	Statistical Analysis Method(s)	Exposures considered	Outcome measures	Confounders controlled for	Results
Desbordes (2009)	To determine links between population health and future inflows of Foreign Direct Investment	Analysis of observational panel data. Annual data, 70 developing countries 1985-2004	Random effects models Ordinary Least Squares models Instrumental variables model to determine disease prevalence effect on future FDI inflows only	Life expectancy Public governance Disease prevalence	Foreign direct investment inflows	Negative FDI Market size Education Physical infrastructure Inflation Foreign debt Open trade policies Property rights Territorial conflict	1 year of increased life expectancy estimated to increase future FDI flows by 3%. IV and OLS. Increase of 1% in HIV prevalence associated with reduction in FDI inflows of 3.5%. 1% increase in population at risk of malaria associated with 0.16% decrease in FDI inflows.
Gustafsson (2011)	To determine links between abolishment of alcohol import quotas or reduction in spirit taxes with increased alcohol related harmful events.	Analysis of observational data before and after a policy change.	Autoregressive Integrated Moving Average (ARIMA) least squares models	Removal of import quotas on alcohol in Sweden Reduction of Danish taxes on alcohol, and increases in quotas	Violent crime, alcohol poisonings and drunk driving incidents	Main results compared to the effect in northern Sweden.	Overall, no association. Alcohol poisonings increased only in post-quota change only in 50-69 age group.

Lead Author and year	Study Aim	Study design	Statistical Analysis Method(s)	Exposures considered	Outcome measures	Confounders controlled for	Results
Jorgenson (2009a)	To determine links between foreign direct investment, industrial pollution, and infant/child mortalities.	Analysis of observational Cross country panel data. Annual data for 35 less developed countries 1980-2000.	For data with less than 10 observations for all countries and variables, Generalised Least Squares (GLS) estimator with random effects. For data with more than 10 observations for all countries, Paris-Winsten cross sectional time series with panel corrected standard errors.	Accumulated stocks of secondary FDI as a percentage of GDP	Water pollution Infant mortality Under 5 mortality	Exports as a % of GDP, domestic investment as % of GDP, Government expenditures as % of GDP, EINGO presence, GDP per cap, urban population, fertility rates (mortality models), secondary education enrolment (mortality models), health expenditures as a % of GDP (mortality equations), selected interactions	Increase of 1 in FDI stocks as a % of GDP associated with 0.078 (SE 0.001) increase in water pollution intensity. Infant mortality and under 5 mortality. Increase of 1 unit of organic water pollutants associated with +13 and +23 infant and under 5 deaths per thousand live births respectively.
Jorgenson (2009b)	To determine links between foreign direct investment, industrial pollution, and infant/child mortalities.	Analysis of observational Cross country panel data. Annual data, 35 less developed countries 1980-2000	Cross-sectional time series Paris-Winsten panel regression Generalised least squares (GLS) random effects panel regression Fixed effects model	Secondary sector FDI, stocks as % of GDP, Exports as % of GDP, Domestic investment as % of GDP	Organic water pollutants per 1000 workers Infant mortality rates	Cross sectional water pollution: GDP per capita, Democratization, secondary education Generalized water pollution: EINGO presence, EINGO intensity, Manufacturing as % of GDP, GDP per capita, Secondary sector FDI Stocks as % of GDP, Exports as % of GDP, Domestic investment as % of GDP Infant mortality GLS RE panel: Organic water pollutants per 1000 workers, GDP per capita, Fertility rates, Democratization, Secondary education, Health expenditures as % of GDP, Health expenditures per capita	Water pollution broadly significantly positively related to secondary sector FDI and exports as a % of GDP. Analysis 2: EINGO presence significantly negatively related to water pollution across all models. Secondary sector FDI and domestic investment still indicated in the same way as analysis 1 Analysis 3: Infant mortality significantly positively related to water pollution across all models. Confounders included are broadly significant.

Lead Author and year	Study Aim	Study design	Statistical Analysis Method(s)	Exposures considered	Outcome measures	Confounders controlled for	Results
Kawachi (2008)	To determine links between flexible work contracts, associated with international trade, and increased reporting of poor health	Analysis of secondary individual level data from the Korean Labour and Income Panel Study 2001. 3369 participants	Propensity score matching estimator to estimate odds ratios of reporting poor health	Exposure to flexible employment contracts.	Odds ratios of reporting poor health by gender and flexible work	Age Educational attainment Household income Marital status Occupation Type of industry Prior health status Prior occupational status	Precarious workers had an unmatched odds ratio associated with poor health of approximately 2 for both genders. Odds ratios were approximately 1.5 using propensity score matching.
Levine (2006)	To determine links between trade openness and measures of child health	Analysis of observational cross sectional data. Observations for variables varied between 96 and 130. Data was from 1990 and covered between 100 and 134 countries in both the economic and health variables.	Instrumental variables regression using 2 stage least squares (2sls)	Proportion of international trade to GDP	Infant mortality rate Child mortality rate Stunting Life expectancy	Instrumental model (for each i and j): Distance between country i and country j Whether i and j share a border Whether i is landlocked Population of i 2sls model (via sensitivity analysis): Income immunization rates Urbanization Share of GDP spent on public health	Infant mortality: geographical trade share coefficient = -0.597. 20% increase in trade corresponds to a 0.1 decrease in log infant mortality. Child mortality: trade share coef. = -0.63 Malnutrition/ Stunting: trade share coef. =-1.11 for log malnutrition Life expectancy: trade share =-0.091 of log life expectancy. 20% increase in trade/GDP corresponded to approximately 0.5 expected years of life

Lead Author and year	Study Aim	Study design	Statistical Analysis Method(s)	Exposures considered	Outcome measures	Confounders controlled for	Results
Martens *et al.* (2010)	To determine links between globalization in its broad definition and mortality	Analysis of observational panel data. Annual/cross-sectional data, 117 countries. Time periods varied significantly based on analysis conducted. Some data is cross sectional and other data is panel.	Spearman's correlation analysis and OLS	Maastricht Globalisation Index (MGI), including breakdown by category: – Political – Economic – Social & cultural – Technological – Ecological	Infant mortality, under five mortality, adult mortality	GDP per capita growth, Prevalence of undernourishment, Total expenditure on health (% of GDP), public health expenditure (% of GDP), total adult literacy rate (% of age > 15), Total primary education enrolment, Secondary education enrolment, Total fertility rate, female smoking rate, % access to improved water source, % access to improved sanitation, DPT immunization, measles immunization	Spearman's correlation: MGI negatively correlated with mortality measures (P < 0.01). Economic globalization correlated -0.421 with IM, -0.428 with under 5 mortality, and -0.270 with adult mortality. OLS breakdown model: Economic globalisation significantly negatively related with all three mortality measures OLS adjusted model: all three mortality measures significantly negatively associated with the MGI. More globalised countries associated with lower mortality rates.

Lead Author and year	Study Aim	Study design	Statistical Analysis Method(s)	Exposures considered	Outcome measures	Confounders controlled for	Results
Moore *et al.* (2006)	To determine links between world system-role of a country, international trade and health outcomes	Analysis of observational international cross sectional data. 116 countries. A variable devised during the study was used for world system role used data from the year 2000 or peripheral years if no data was available.	Network analysis to categorise each country's role in the panel, and OLS for the final analysis	World system role and trade as a % of GDP	Infant mortality	GDP per capita, Aid per capita, tropical climate, landlocked country, tropical country, Female literacy, Voice and accountability, political stability	The role of periphery 1 was significantly positively related to infant mortality (0.257, t = 2.89) and trade % of GDP was not significant in either model. Suggests world system role is more important or the same information as international trade.
Oster (2012)	To determine links between export of goods between sub-Saharan African countries and HIV incidence	Analysis of observation panel data. Annual data including 36 countries 1985-2007	Fixed effects panel estimation	Exports of goods	HIV incidence, calculated from UNAIDS prevalence estimates.	GDP per capita Country fixed effects Time fixed effects	A doubling of exports was associated with between a 10% and doubling of HIV incidence depending on data used.

Lead Author and year	Study Aim	Study design	Statistical Analysis Method(s)	Exposures considered	Outcome measures	Confounders controlled for	Results
Owen (2007)	To determine links between openness to international trade and health outcomes.	Analysis of observational panel data. 219 countries between 1960 and 1995.	Fixed effects and dynamic panel models.	Multiple: (exports +imports)/GDP Black market premium Sachs-Warner Index Imports/GDP Health-adjusted imports	Male life expectancy Female life expectancy infant mortality	Lagged health, Per capita GDP, population growth, secondary school enrolling, interactions of openness	FE model: All five results present significant coefficients indicating that more openness is associated with less mortality. Interaction of GDP per capita and openness mixed result. Most coefficients indicate a positive association with life expectancy. Dynamic panel model: Less conclusive. Openness is not significant in most measures. Health-adjusted imports/GDP as openness measure indicates significant positive relation to life expectancy.

Lead Author and year	Study Aim	Study design	Statistical Analysis Method(s)	Exposures considered	Outcome measures	Confounders controlled for	Results

A.5 Quality assessments

A.5.1 Cross 2009

Non-trial quality assessment Fill-in sheet

Please use the following sheet to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: Does farm worker health vary between localised and globalised food supply systems?

Overall judgement: Low quality study

There were judged to be serious issues with the quality of the data used in this study, regardless of how novel, original and insightful the study was. Further, the analysis method was not applicable to this data considering the true complexity of the relationship between work and health.

Domain 1: Quality from the data
Judgement: Low Quality

Justification: The data collected was individual level HRQoL data. The sampling method was 'opportunistic' and 'non-systematic' i.e. any farm that was willing to let its workers complete the surveys used in the European sample. This was not randomised, and was highly likely to affect the validity of the results. The authors themselves acknowledge that the sample was both not representative (Top left of page 1007) and dictated by the willingness of farms to participate (further down the same paragraph). An obvious question was this: Why would a farm with lax safety policy, or worker related problems affecting the health surveys volunteer to participate in the study, regardless of whether results are anonymous or not? This raises a serious concern that any results are upwardly biased in the European sample.

Further, recruitment was not consistent in different locations. African workers were recruited on an individual level face-to-face basis by researchers from Kampala University. All of these farms were also within a specific geographical proximity of Kampala, which is not true of the recruitment strategy at other locations. It was felt that this may have affected the internal validity of the data being analysed. This was mentioned in the discussion, with the authors stating the difference in reporting across the various data collection methods.

It was therefore felt that selection bias may have been a significant concern. Inclusion of data collection method, or country (as it was the same information in this case) as dummy variables to a regression would identify the significance of the data collection method to the results, and this, or any other adjustment for bias was not carried out. Therefore, there was a high risk of biased results and no attempt to address this. Overall, data should be judged to be low quality based on this issue.

Group sizes were extremely unbalanced in terms of clusters (e.g. 2 exporting farms Vs. approx. 50 non-exporting farms in Kenya). Although the two farms sampled were employing large numbers of workers (1000+), there was no indication in the paper of how many survey responses were collected from these farms. This is another quality issue due to unobserved clustering effects. If, for example 99% of data was collected at one farm and 1% the other, and the healthstate of workers was significantly different between the two, the results would lack representativeness in terms of the two locations surveyed, and this would not be reflected in the results.

Self-reported health related quality of life is known to be affected by many factors that differ from country to country. Therefore directly comparing results between countries without controlling for differences (by perhaps including country as a dummy variable to a regression analysis, or country fixed effects, or development of weights based on pilot study information) was judged to be potentially spurious. If Kenyan nationals typically assign more positive responses to the same health related issues as in other countries, then two populations with exactly the same level of health would report systematically different sets of responses to the survey. This reduces the accuracy of the results, creating another data-related limitation.

Only Kenyan data was broken down into export and non-export focused production, so the point of comparison between countries was not like-for-like. If export farms are indeed associated with better health, then comparing farms in general to them would negatively bias results, because the aggregate data would be pushed up by the export farms it contains.

Any of the above issues would individually lead to a quality assessment of medium. Therefore overall, this domain must be judged to be low quality.

Domain 2: Quality associated with data approach and analysis method
Judgement: Medium quality

Justification: The primary analysis method was non-parametric t-testing and ANOVA, and was adjusted for the distribution of the data. This did not control for confounders. Due to the complexity of HRQoL, and the unlikely situation that working conditions are the sole driver of health, it was felt that study quality in this domain was medium.

Further, a regression analysis was conducted, but this is only to seek out the role of income as a confounder. A significant relationship is identified as a result of this regression analysis. However, the primary analysis method was not adjusted to adjust for income as a confounder.

Further, it was judged to be unlikely that the only confounder to health in this situation would be income. Overall, the analysis method was judged to be unsuitable for judgment of a complicated relationship.

Domain 3: quality in presentation of results
Judgement: High quality

Justification: The lack of a separation between export and non-export farms in the countries other than Kenya seems to be a data collection issue rather than omission from the results. The presentation of the results that they have seems to be thorough, and does not contribute to the quality as a result.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: high quality

Justification: The conclusions are highly likely to be biased, but this is chiefly because of the data. The interpretation of results itself, in terms of the way it is conducted is thorough. Further, in the discussion, many of the weaknesses in the study are discussed, and the reader is cautioned to not read into the results too much

Domain 5: Other risks of bias
Judgement: N/A
Justification:N/A

A.5.2 Cross 2010

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: The potential impact on farmer health of enhanced export horticultural trade between the UK and Uganda

Overall judgement: Medium quality Similarly to the previous study by Cross et al. There were felt to be significant data related issues, but these were not judged to be serious enough to judge the whole article as low quality. However, it was felt that the results and inference in this study should be treated with caution.

Domain 1: Quality from the data
Judgement: Medium quality Justification: unlike Cross 2009, the dataset was limited to farms producing the same crops to control for differing health associations with different cultivations. Data collection for Uganda was handled by Makerere University (in Kampala), and is likely the same uganda dataset as Cross 2009. As a side note, this dataset separated exporting farms for non-exporting farms, which they did not in Cross 2009, raising a concern over the presentation of complete results.

The collection method varied between Uganda and the UK. UK farms were recruited by 'pre-existing contacts', websites and via phone directories.

Partially for confidentiality reasons (section 2.3.1), there was no indication of how many UK farms were contacted for recruitment, and thus the proportion that accepted is unknown. Eight farms were recruited into the study and workers within these had an average response rate of 56%. The subset of farms that did not agree to participate could have done so for a reason related to worker health, regardless of confidentiality being offered. For example, during a harvest period, farms may be unwilling to allow workers the time out it took to complete the data collection.

For Uganda, there was no indication that permission was sought to give questionnaires, indicating that recruitment was more on a face-to-face level. Farms had the same (or very similar) crops to the sample of UK farms, and all but one were within a 2 hour drive of Entebbe international airport. If farms close to Entebbe airport were better or worse than others in Uganda regarding worker health, the study did not represent Ugandan export worker health in general.

Differences in data collection method were still significant between the two samples, and this could have affected survey responses. However, some effort was made to remove the major issues in the earlier papers. It was felt that geographical bias could have affected the Ugandan sample, and self-selection bias could have affected the UK sample. Therefore, a score of medium quality was awarded.

Overall, the quality of data was on the low-end of medium.

Domain 2: Quality associated with data approach and analysis method
Judgement: Medium Quality Justification: Since the primary analysis method was non-parametric t testing for differences in score without adjustment for confounders, it is unclear how much major confounders affected the results.

The results of both countries were compared to USA population norms. There was no way of capturing any possible effects on study results, as the authors confirm that population norms for Ugandan SF-36 do not currently exist. If the US population norms are closer to the UK than they are to the Ugandan norms, this may have made the results in one country seem more positive than they actually were.

Domain 3: quality in presentation of results
Judgement: Medium quality Justification: Table 1 shows the disaggregated (by gender) survey response averages for the UK, and their comparison to US pop norms. Table 2 shows Ugandan averages and comparison to US.

If a superscript of 'a' after the p-value was given in table 1, this meant that UK score was significantly lower than US population norm in table1. Superscript of 'b' meant UK score > US population norm. However, the opposite is true of table 2, where 'a' means that Ugandan score is higher than the US population norm. This is rather misleading and confusing. Further, although it is represented in tables 1-3, the text suggests that the results are far more conclusive than they in fact are. Many of the results are insignificant. Although the way that the results have been presented makes it difficult to read, leading to judgement of medium quality in presentation of results.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: Medium quality Justification: For the most part, space constraints have made the regression results difficult to read, but the inclusion of the important results in the analysis and discussion sections seems to be broadly presented. It was felt that the discussion did not raise data collection and analysis method limitations sufficiently.

The authors went on to present OLS results of health states against various explanatory variables. They show a difference in income by gender, and control for it. They also demonstrate that the income distribution is very unlikely to be normal, yet do not appear to have taken logs to reduce the effect. Further, it is demonstrated that house type, bicycle ownership and radio ownership were related to income (similarly to Cross 2009), and they are all related to health score. This would suggest that robust standard errors be used to alleviate the effect of muliticolinearity on the model. Finally, the variable 'farm' seems to describe which farm the worker's data has been collected from. However, there only appears to be one variable presented for this, meaning that the author used allocated farm id as a variable, making the coefficient meaningless (unless the data is ordered in some way). Farm id's significance suggests that farm fixed effects would be a more consistent estimator.

The overall effect on the result of these issues on internal validity is difficult to gauge.

Domain 5: Other risks of bias
Judgement: Justification:

A.5.3 Kawachi 2008

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: Globalization and worker's health

Overall judgement: Medium quality Overall justification: Quality issues were primarily with respect to Domain 1, but Domain 4 also raised a minor issue. Overall, the quality of the evidence was judged to be medium

Domain 1: Quality from the data
Judgement: Medium quality Justification: For judging the situation in Korea in 2001, this would appear to be a relatively large, representative dataset. That being said, the author states that the prevalence of non-standard employment rose sharply in the late 90s. The panel data is from 2001, so as a consequence, was this a snapshot of the situation during a rapid change? If so, were the results out of date by publication? If there has been growth in non-standard employment due to more globalization, and that is associated with reporting of poor health, then was the optimal cross section in 2001?

This is a short article/letter and does not go into detail with respect to data quality. There appears to be no mention of either missing data or the representativeness of the data used. The data included 1991 male and 1378 female respondents. From the way that the logit model to calculate propensity score was described, this also provided information on age, education, household income, marital status, and occupation, type of industry and historical health status and occupational status.

As insufficient information was provided to make an informed judgement on Domain 1, it must be judged to be medium quality.

Domain 2: Quality associated with data approach and analysis method
Judgement: High quality (from the method itself. See domain 4)

Justification: The method is propensity score matching estimation using logit models to calculate the propensity scores (i.e. probability of being a precarious worker given that individual's set of descriptor variables, described above). This is a way of attempting to enable causal inference of results by removing the confounding effects of the control variables used in the matching method. If Zi (the controls) does not contain enough information to explain the individual's propensity, then the model is subject to bias. A list of confounders included in the Z equation is given, and appears to be a reasonable selection, even including industry, job title and past health status of the individual. I would then argue that given a strong list of confounders in Zi, the analysis method was appropriate.

The caliper width is 0.1, which seems reasonable. Individuals could be matched with others that have propensity scores up to 0.1 different from their own. Ideally this is close to 0, but that is often unfeasible considering quantity of data.

Domain 3: quality in presentation of results
Judgement: high quality Justification: The only result presented is a graph of the odds ratios of poor self-rated health status by precarious/not precarious and male/female. The matched analysis is presented next to the unmatched, giving a fair representation of the difference made due to PSM estimation.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: Medium quality Justification: We were not presented with the predictive power of the propensity score model, and so we are unable to establish whether confounders were properly accounted for. One minor point is that the authors did not conduct sensitivity analysis to test whether the matching approach selected was suitable for the sample population. Use of various matching methods is recommended, as it is difficult to establish the suitability of a matching approach.

Finally, Rosenbaum tests for hidden bias were not used. It was difficult to impossible, then, to discern internal validity issues with the model results (Again PSM was a relatively new method, so perhaps sensitivity analysis using multiple matching methodologies and Rosenbaum tests were not in common use).

The analysis interpretation includes general statements about movements towards flexible employment in neo-liberal, globalized systems (with the Caveat that EU directives have sought to reduce discrimination against part time workers since 1997). The result provided an indication that precarious work contracts increase likelihood of reporting poor health status, but the data used was from a cross section of one country.

Domain 5: Other risks of bias
Judgement: N/A Justification:

A.5.4 Bozorgmehr 2013

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: Trade liberalization and tuberculosis incidence: A longditudinal multi-level analysis in 22 high burden countries between 1990 and 2010

Domain 1: Quality from the data
Judgement: High quality Justification: Additional data is available via an online appendix. There is in fact a whole section of this appendix dedicated to the presence of missing data and the approach to it. Missing data was addressed when defined as 'intermittent' (i.e. just 1 year of missing data surrounded by data) by linear interopolation. As the observation period is reasonably large (20 years), small points of interpolation to increase sample size and completeness of data are unlikely to affect the overall result. In the cases where 2 or more years were missing in a data vector, 2 years were carried forward from the last point of data, with the remaining gap being left blank. Neither of these techniques were likely to affect the result of the study.

However, the GINI coefficients were noted as having more than 80% missing data, and this was still defined as 'intermittent' in the appendix table (table 4 in the online appendix). This seemed very high considering that intermittent suggests gaps of 1 year between data points.

All countries were dropped at specific years as they all had missing data. This was considered a minor concern unless the outcome measure or explanatory variables in these years were systematically different from the years surrounding the gap.

Overall, the missing data issues are addressed very well, and the result is that the data was felt to be of a high quality

Domain 2: Quality associated with data approach and analysis method
Judgement: High quality Justification: Data approach: The authors used random and fixed effects models, adjusting for time invariant and (parametrically assumed) time variant unobserved heterogeneity (separately). Further, the authors considered a wide range of confounders, assessed the quality of each one, and implemented those they assessed as most fitting. Finally, data not normally distributed was transformed accordingly. This was a reasonable data approach and worthy of high quality.

Methodology: The paper used various methods to establish a multi-level model. According to the theoretical frameworks, linear regressions were used to make links. Where non-normal distributions were detected, variables were transformed using natural logarithms. This seemed reasonable.

It would appear that the Gauss Markov assumptions were tested extensively (page 7 in paper), and adjusted for where necessary using robust standard errors, and adjustments to estimation method. As with the primary analysis method, this controlled for confounders, and included country variables. The multi-level analysis was judged as having a high quality.

The primary study method was both fixed and random effects models. The authors used a variable 'time since 1990' to account for time variant characteristics. As both random and fixed effects were used, and the appendix included various results, there was a point of comparison for readers to use in order to decide the internal validity for themselves.

Overall the approach to data and analysis method were very reasonable, and were judged to be of a high quality.

Domain 3: quality in presentation of results
Judgement: High quality Justification: Results not presented in the paper are openly available in the online appendix. This is the most extensive presentation of results in the literature accepted into this review. There is no evidence that results were omitted.

Further, it would not appear that there is any strategic emphasis on particular results in order to influence a reader's interpretation.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: High quality Justification: the discussion seemed very thorough. All confounders (including the trade variables) were discussed fairly and correspondently to the results presented in tables and the appendix. The discussion of results and inference were judged as having a high quality.

Domain 5: Other risks of bias
Judgement: Justification:

A.5.5 Gustafsson 2010

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: Changes in alcohol related harm in Sweden after increasing alcohol import quotas and a Danish tax decrease an interrupted time series analysis for 2000-2007

Overall judgement: High quality Overall justification: There are some minor issues with presentation of models, and underlying problems with the data, but overall, the likelihood of the conclusion being inaccurate was judged to be low.

Domain 1: Quality from the data
Judgement: (precariously) high quality Justification: The justification for the use of alcohol poisonings, drunk driving and violent crime assumes that proportions in comparison to alcohol consumed remain fixed as exposure increases. That is, for every unit consumed, the probability of violent crime, drunk driving or poisonings remains the same. Correlations are used to demonstrate the validity of these as means to measure alcohol abuse. It was difficult with existing data to test whether the relation between alcohol abuse and detected cases of the three indicators was linear. But, the overall effect on the conclusion of the paper was likely to be small (yet dependant on the magnitude of the change in alcohol abuse) if it is in fact not.

The hospitalisation data was judged to be internally valid and representative for Sweden, and slightly less so for crime data. This was because the authors did not give the same supporting statements to that data, and the data is not restricted to alcohol related crimes. However, a fundamental flaw was that all three indicators were vulnerable to changes in detection rates during the sample. Changes to national tax law are media issues bringing attention to issues such as alcohol abuse and violence. It would be unclear whether relevant services would react to them through striving to detect relevant crimes or negative health consequences.

Overall, it is considered that these concerns were worth raising, but unlikely to affect the overall result, unless the detection rate was affected by the policy change.

Domain 2: Quality associated with data approach and analysis method
Judgement: High quality Justification: The authors avoid biasing violent crime by removing discrete events and interpolating the preceding and following years. This was judged to be a reasonable approach to avoid skewing the distribution the crime figures. The authors also controlled for confounders using a proxy to a control group, and took logs of the harm indicators to control for non-normal distributions.

The control was data from the North of Sweden, which they argued was unlikely to be affected by the policy change. They stated just before the results section (bottom of the left column) that "It should be noted, however, that the findings for southern Sweden were little affected by the inclusion of northern Sweden as a control in the analysis and that the main results remained without this control variable (analysis not reported here)".

The authors used autoregressive integrated moving average modelling (ARIMA). Reading from Greene 2002, this is a lagged integrated model. The authors took the first difference of all the variables and included lags, then performing OLS. In order for this to be valid, data must have been stationary and should not have had any systematic seasonal differences (e.g. alcohol demand before Christmas, other festivals). To address the first issue, the authors use the Augmented Dickey-Fuller test after taking first differences and find that data are stationary. For the seasonal issue, they use the 12th monthly lag, so that each variable becomes year-on-year change.

It can be judged that the data approach and the analysis method are both robust and thus the domain scores high quality.

Domain 3: quality in presentation of results
Judgement: High quality Justification: Results, regardless of support for the hypothesis are reported thoroughly.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: High quality Justification: The authors confirmed the robustness of the model in the methods section. Most of the testing required to demonstrate the internal validity of the estimation method and data was done pre-estimation and is therefore judged in domains 1 and 2.

The authors found a correlation between the tax decrease and quota removal, suggesting confounding in an analysis including both, leading them to be somewhat inconclusive in their findings. This suggests a high study quality with respect to steering of discussions and interpreting the analysis results. Overall score remains high.

Domain 5: Other risks of bias
Judgement: High quality (minor issue) Justification: As stated by the authors, other changes that could affect detection and reporting of the three indicators would potentially bias the study, but as a judgement, the risk of this has been decided to be low.

A.5.6 Oster 2012

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Overall score: high quality A large panel was used, the analysis method was reasonable and inference was also reasonable. Overall the quality of the research was high.

Domain 1: Quality from the data
Score: High quality Data on incidence was predicted by UNAIDS in 2008. This covered the range 1990 to 2007. These were estimated values and HIV data is known to be difficult to accurately collect. However, the author makes this very clear to the reader, and notes that the information is based on the best available information at the time. The issue with this data is that quality related problems are unobservable to the reviewer.

Data on exports was from 3 sources. These were the World Development indicators, NBER United Nations Trade Data and Comtrade. Following methodology from a previous paper (Feenstra et al. 2004), the second two data sources are combined to create a dataset covering the period 1985-2007. This data only covers “Major exports”, but the author assures the reader that this covers almost all exports in sub-saharan Africa.

The overall completeness of the data was not discussed in the paper, but was not an issue for trade and made clear through appendix table 1 for HIV. UNAIDS data existed for the whole period for all 36 countries in the panel. However, mortality based estimated data was only available for 12. As the primary analysis utilised the UNAIDS panel, this was not felt to be an issue.

The issue of trustworthiness of the data was felt to be noteworthy, but unlikely to cause serious internal validity issues in the final estimates. Section 3.1 explains the HIV data used. It is noted that until recent years, when population based testing became the favoured methodology, data on HIV was unreliable and difficult to collect. Further, UNAIDS estimates of historical prevalence of HIV are not consistent across reports. Although the author uses a single report, which provides estimates covering the period 1990 to 2007, this is likely to not be consistent with newer reports or previous. This raises questions about how accurate the UNAIDS data is, and therefore how reliable empirical data analysis based on it is.

Overall the data used was felt to be of a high quality given that the author makes it clear that the study is evidence for or against a relationship between international trade and HIV transmission, and not a demonstration of causality.

Domain 2: Quality associated with data approach and analysis method
Score: High Quality The data did not require much manipulation in order to be used in the analysis, and the methodology used took unobserved heterogeneity across both individuals and time into account.

The control variables included were GDP per capita, country fixed effects and time fixed effects. Although this was felt to be far from exhaustive, it was not felt that the overall estimation was seriously biased by other confounders.

The estimation methodology was fixed effects. The authors used fixed effects for time as well as country, meaning that time variant characteristics were controlled for additionally to unobserved heterogeneity between individuals. The authors did not use a Hausman or alternative test, so it is not possible to know whether the assumption that the regressors were not associated with the random effect was likely to be violated, and by association whether a random effects model would be asymptotically unbiased. However, as a fixed effects model is asymptotically unbiased in the absence of endogeneity, this reflects well on the internal validity of the analysis.

Overall, the estimation methodology as well as the way that the data was treated was felt to be reasonable.

Domain 3: quality in presentation of results
High quality The primary results are presented in full, and (very small) graphs are provided showing the whole panel's export and HIV data for reader inspection. Overall, results were presented well and there is no reason to believe that results were strategically presented.

Domain 4: Quality from post estimation testing and analysis interpretation
Score: high quality Two sensitivity analyses were conducted. The first was to test for level effects. The second was a set of different lagged models to test whether different lags capture more or less of the effect. This was felt to be sufficient and reasonable.

The author tests whether the process of generating incidence data undertaken was creating the relationship between exports and incidence. The author also goes onto discuss causal mechanisms, but does not claim that the evidence presented is definitive proof of causality.

Overall, it was felt that robustness testing was thorough, and discussion of the results was very good.

Domain 5: Other risks of bias
N/A

A.5.7 Alsan 2006

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: The effect of population health on Foreign Direct Investment Inflows to low and middle income countries

Overall score: High quality

Justification: Although the panel excluded oil dependant countries, it was judged that the data was representative with respect to the hypothesis. The methodology appeared reasonable and adjustments to the data were made to accommodate that method. Overall study quality was high.

Domain 1: Quality from the data
Judgement: High quality

Justification: the panel included 74 countries, and these were listed in the appendix. The amount of included countries appeared a representative sample of each group. However, the dataset did not cover every country. In fact, some countries were excluded based on their primary export (petroleum). It was argued that the relationship between health and FDI was biased by the oil exporters, which may be the case. For the purposes of capturing the general relationship between trade and health, it was felt that this did not significantly contribute to a risk of the study being biased. The data utilised was averaged over 10 years for each country, reducing the impact of missing data at the cost of precision. This was another minor quality issue. Overall, the quality of data was high in this study.

Domain 2: Quality associated with data approach and analysis method
Judgement: High quality

Justification:

Data approach: unobservable heterogeneity between countries was taken into account via the methodological choice (country fixed effects). Further, time dummies were used to factor out particular events that would otherwise bias the results.

Methodological approach: Methodology was panel regression. Non-normally distributed data was logged to adjust, and the other adjustments made to the data were judged to be reasonable. Overall, the methodological selection did not reduce the quality of the study

The range of control variables included was judged to be sufficient to reduce confounding to a minimum.

Domain 3: quality in presentation of results
Judgement: High quality Justification: Summary statistics and a correlation table were provided before the regressions to enable the reader to judge for themselves the strength of the relationships in question. The presentation of results was thorough. There was no indication that results were omitted from the study

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: High quality Justification: The authors followed up the initial analysis by adding additional control variables to test the robustness of the results. Further, all variables were discussed in the results, and the authors stated that other variables and stratifications were used. There is no indication that the analysis interpretation reduced the study quality.

Domain 5: Other risks of bias
Judgement: N/A Justification:

A.5.8 Bergh 2010

Non-trial quality assessment Fill-in sheet:

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: Good for living? On the relationship between globalization and life expectancy

Overall: Medium quality Overall justification: The model is robust and the post estimation testing is also very strong. However, the omission of 24% of the panel meant that domain one was awarded a medium quality. Some testing or even a list of countries included would have addressed this issue to some extent.

Domain 1: Quality from the data
Judgement: Medium quality Justification: The authors addressed missing data by omitting countries from the panel that had incomplete datasets. However, there was no indication of testing to see if the omission affected the results or not (e.g. testing whether averages for variables were significantly different when including the data with missing points). Without testing of this sort, and with the significant amount of countries dropped from the panel (29/121 countries dropped), the effect of this omission on estimation results was unclear. Therefore, there is no choice but to award data quality a score of medium, despite all other domains being high quality.

Domain 2: Quality associated with data approach and analysis method
Judgement: High quality Justification: The authors took into account both confounders and non-normally distributed data by including control variables and taking natural logarithms. There was a discussion of previous studies that established general links with growth, wealth and so on and life expectancy. They used this reasoning and previous discussion to justify the inclusion of control variables to include. The authors acknowledged 'the non-linearity between globalization and life expectancy' by taking logs of the primary input variable, the KOF (and breakdown of KOF into domains, see main text for reference and definition). Finally, dummies for both period and country were used to account for time invariant differences between countries. Overall, the data approach was strong.

The primary analysis methodology was fixed effects panel regression. Lags of the KOF and its disaggregation categories were included in the model. The authors believed that spherical errors were present and reference this approach to a monte-carlo simulation based methodological paper, citing the recommendations that those authors made. Estimations also use white-adjusted standard errors.

Finally, a sensitivity analysis was conducted by repeating the model using a random-effects model and using a different globalization index (The CGSR index). Overall, this approach is robust and caters to issues with the panel. Domain 2 was awarded high quality.

Domain 3: quality in presentation of results
Judgement: High quality Justification: The presentation of results was thorough and included full representation of the random-effects sensitivity analysis, in which various combinations of the control variables were introduced to test the reaction of the model. Very thorough and a model for other studies in this area.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: High quality Justification: Again, the sensitivity analysis presented in table 4 demonstrated the robustness of the model. Results were similar in the baseline model with a random-effects approach. All important conclusions were mentioned in the discussion and conclusions. Results were also compared to those using a different globalization index. This was judged to be very important to conduct, as the different indices rank countries very differently (as can be seen in the paper by Zinkina, Korotayev and Andreev called 'Measuring globalization: Existing methods and their implications for teaching global studies and forecasting')

Domain 5: Other risks of bias
Judgement: N/A Justification:

A.5.9 Desbordes 2008

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: Public Governance, Health and Foreign Direct Investment in Sub-Saharan Africa

Overall quality: High quality

Overall justification: There are a few minor issues, but overall the quality of the study is high.

Domain 1: Quality from the data
Judgement: High quality

Justification: The authors explained that FDI was a bad proxy for multinational enterprises' actual activities immediately, but justify its use as it is the only available measure. Although results of the test are not presented to the reader, the author states that country samples of FDI data "hardly alter" when all available observations are included, even if there is missing data. It is implied that all other data except education data was complete for the sample. Education data was linearly interpolated across gaps.

The author argued that the sample was representative. They used the same reasoning as above to state that countries with missing data were unlikely to have missing data statistically significantly different from the existing data. Thus, it was an implicit argument that missing data is missing-at-random, thereby suggesting the sample is representative.

Overall, it can be argued that the quality was high. As the hypothesis regards FDI rather than Multinational Enterprise (MNE) conduct, it did not matter that FDI was a loose proxy. Finally, it was suggested that the data is complete and representative.

Domain 2: Quality associated with data approach and analysis method
Judgement: High quality Justification: Transformations of the data were used to account for non-normal distributions.

Unobserved heterogeneity was addressed through the method selection and introduction of time period dummies. Wide ranging control variables were also used to control for confounders to the issue. Random effects models were described as inferior due to fixed effects' elimination of time invariant differences between countries. However, there was no indication that a random effects model was run and compared to the fixed results to observe significant difference in coefficients (hausmann test). As consistent estimates were not tested for using this test, it became difficult to gauge the quality. However, as the primary focus was to account for between country differences, the models were shown to be robust and account for high proportions of the variation in dependant variables, the domain scored High quality.

Domain 3: quality in presentation of results
Judgement: high quality

Justification: Reporting of results is thorough and there is no evidence that any results have been omitted from the paper.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: High quality

Justification: Presentation of a hausmann test would have been preferable, but considering the explanatory power of the models and extensive discussion of the results, this was likely a minor issue. Overall domain four scored high quality.

Domain 5: Other risks of bias
Judgement: High quality

Justification: Although it was argued that including or excluding the data with missing values did not affect regional/country calculations, the results of testing were not presented to the reader, so there was no way of knowing whether this was formally conducted or not.

A.5.10 Jorgenson 2009

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: foreign direct investment and the environment, the mitigating influence of institutional and civil society factors, and relationships between industrial pollution and human health: a panel study of less developed countries

Overall judgement: Medium quality Overall justification: The problems with the data are potentially extensive, but it is very unclear to the reader. However, it is also not significantly affecting the overall conclusion. The overall study quality was medium.

Domain 1: Quality from the data
Judgement: Medium quality Justification: The period of the panel data was 1980 to 2000. This was restricted to less developed countries. The classification of less developed was clearly presented. The issue of missing data was addressed by allowing sample sizes to vary between models. Since these (whole panel) sample sizes varied by variable significantly (49 to 519), it brought into question the representativeness and/or accuracy of the very small samples. If data was not missing at random, then important links between FDI pollution and health could have been missed, i.e. type 2 errors may have become more likely. Further, the mean number of observations per country reached as low as 2.1, and although the authors listed countries included in the sample in the appendix, they did not state the N of each country by variable or any indication of it. In isolation, the data itself could present some risk of both type 1 and 2 errors. Either a subset of the whole panel (the subset with more complete data) is over-emphasised and has a stronger connection between the variables, leading to type 1 error, or vice versa leading to type 2.

Additionally mentioned in the results section was weaknesses in the collected data. Domestic investment was for all sectors, and not just manufacturing, and there was no information on the distribution of this investment across sector. Interpretation of those results was limited to acknowledgement of their significance, which the authors comply with. Conclusions based on data where weaknesses such as these were announced were avoided throughout, and as a result this does not worsen the quality of the study.

This domain was judged as medium quality, as the extent of the problem could not be discerned, and there is no indication of how complete the panel is.

Domain 2: Quality associated with data approach and analysis method
Judgement: High quality

Justification: The dependant and independent variables were listed and discussed extensively. This included discussion and justification of manipulation. Non-normally distributed data was logged and lags were introduced to models to control for serial correlation. This was a reasonable approach.

The analysis method was split into two based on sample sizes. Small panels (defined as niâĽď10 for any i) used GLS random effects panel estimation with robust standard errors. This was justified via the value of the increased degrees of freedom in GLS estimation in comparison to other methods. As some of the countries (not specified which ones) had as little as 2 observations, the value of this was clear.

For larger panels ($n_i > 10$), Paris-Winsten cross sectional time series was used with panel corrected standard errors. Further, in both methods, dummies for time period were used. However, dummies for country were only used in the PW models, as the other method was random effects and assumed country effects were random. To control for this, hausmann tests were used and showed that FE and RE models yielded similar results. The additional degrees of freedom from random effects was deemed superior to fixed effects estimation.

Overall, the approach to the data and the analysis method were both reasonable.

Domain 3: quality in presentation of results

Judgement: High quality

Justification: The only set of results omitted to the study was the hausmann test results, which would have required another regression table. The authors assured the reader that the difference between models was small, and this must be taken on faith. This only affects models 5 and 6, however, and is therefore unlikely to affect the overall result. Other than that, the presentation of results seems very thorough, and there is no evidence of omission based on findings.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: High quality

Justification: As in domains 2 and 3, post estimation testing seemed thorough, although the result of hausmann tests were not presented. Quality of analysis interpretation is high as inconsistencies across models are explained well and discussion of inconveniently insignificant results was not avoided.

Domain 5: Other risks of bias
Judgement: N/A Justification:

A.5.11 Jorgenson 2009

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: Political economic integration, industrial pollution and human health: A panel study of less-developed countries, 1980-2000

Domain 1: Quality from the data
Judgement: Medium quality (for the health outcome)

Justification: Extensive description of problems with data was provided. Also in the appendix was an inclusion table, showing which countries' data was included for each analysis. All countries were included for the infant mortality analysis, but for the other three hypotheses, the same countries were excluded throughout. The number of countries excluded was small. These exclusions were unlikely to affect the result of the study.

For infant mortality, the authors pointed out clearly that some of the data used was estimated based on 'census, survey or registration data'. This highlighted some vulnerability of the study to bias depending on that estimation method. Authors simply point out that 'indirect estimation' is required in non-complete vital-registration system.

The quality of the data was medium.

Domain 2: Quality associated with data approach and analysis method
Judgement: High quality

Justification: The author considered individual country effects, adjusting the methodology to account for it. Confounders were also addressed, discussed and controls introduced to all models. Models were presented without using controls and then with for the reader's comparison. The data approach was high quality.

The author used generalised least squares random effects panel models to link infant mortality to water pollution, which in turn was linked with international investment. The robustness of the model was checked through sensitivity analysis using different sets of variables. Further, the author used natural logarithms for non-normally distributed data. However, the model did not seem to take time variant characteristics into account as the other study by Jorgenson did. It was highlighted in the notes section that use of a fixed effects model had similar results (i.e. a Hausman test was conducted, suggesting the use of random effects estimation), but these were not presented. Overall, the quality of domain 2 was high.

Domain 3: quality in presentation of results
Judgement: High quality

Justification: As mentioned in domain 2, the author claimed in the notes that FE models have similar results. However, no indication of this was given. Further, note 10 stated that when including the international trade data to the infant mortality model, each investment variable became insignificant. These results were not provided in the paper however.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: High quality

Justification: The discussion and results presented were thorough and extensive. All significant relations shown in regressions were mentioned in the text, and even the relative strength of models after including control variables was discussed. Overall, domain 4 scored very highly.

Domain 5: Other risks of bias
Judgement: N/A Justification:

A.5.12 Levine 2006

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Domain 1: Quality from the data
High quality

The study is a cross-sectional study including spatial elements. The cross section includes a panel of 130 countries for most variables, however this is slightly less for some, falling as low as 96 for levels of Wasting. However, there is complete data from trusted sources (penn tables and World bank development indicators) for infant mortality, GDP per capita, geographical trade share and actual trade share. 4 countries were dropped from the initial 134 country sample as they all were part of the Soviet bloc and were encountering effects likely to affect all parts of the model (Bulgaria, Hungary, Poland and Romania).

The issue of measurement error is also highlighted and discussed.

Overall, the data is very old for the year the study was published (1985 for the spatial model 1990 for the main equation and 2005 for research). If the relationships between either spatial elements and trade or trade and child health have changed over time, this study is not estimating the relationship today.

Further, the data for the instrument and the main equation are 5 years apart. If there was a level (regardless of spatial elements) increase in international trade between 1985 and 1990 across the world, this does not affect the validity of the equation as an instrument, since the instrumental model is simply under-estimating the coefficient of geographical trade share, rather than the strength of the relationship between geography and trade share.

The quality of the data in this study is therefore judged to be high due to being mostly complete and representative. The issue of being out of date is potentially affecting how relevant the results are today, but not the validity of the actual research.

Domain 2: Quality associated with data approach and analysis method
Data treatment: The method used takes into account the difference between countries through inclusion of geographic variables to the instrumental model.

Method: The method is instrumental variables regression in the form of 2 stage least squares. The authors do not use a heckman procedure, and the instrument used is significant.

The instrumental model was found by looking up the paper originally using the instrumental equation with the same data (Frankel and Romer 1999 — Does trade cause growth?). The spatial model used gives a correlation between actual trade share and estimated trade share of 0.62, and an R2 of 0.52 when adjusting for population and country area. As trade cannot physically affect geography, I would argue that it is exogenously generated.

Overall, I would argue that the quality of the research with respect to the methodology is high. This is due to the reasonable approach from the authors and probable exogeneity of the instrument.

Domain 3: quality in presentation of results
High quality

A slight mistake in the text suggesting that one of the results that was included was not. This was the child mortality result on pages 545 and 546, for which it states the result is not provided, but it is in Table 3 (column 2). Other than that, no issues were detected with respect to presentation of results.

Domain 4: Quality from post estimation testing and analysis interpretation
High quality

There is extended discussion of instrumentation, identification of variables and using a range of different child health measures to test the sensitivity of the results. Further, there is a section discussing the causal channels between trade and child health. They acknowledge that when their models are conditioned on some variables, the effect sizes change, going on to discuss reasons for this, and the relative roles of each variable conditioned upon.

Following this, the authors conduct robustness checks. They do this by restricting the sample of countries using various criteria, finding that there is not effect on the results. Finally they condition on shocks to trade, including time variables and so on. It was felt that post estimation testing was excellent in this work.

The way that the analysis was interpreted was felt to be reasonable and fair. Their conclusions are clearly built from the results and there are no leaps in the anlalysis

Overall, domain 4 was high quality in this work

Domain 5: Other risks of bias
N/A

A.5.13 Martens 2010

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Domain 1: Quality from the data
Judgement: High quality Justification: The primary input variable was an indexed number to indicate the level of globalization in a country. It was also an index developed by the first author of the paper. This raises some minor suspicion of a conflict of interest, however the author gives a thorough explanation of how the index is calculated, and does not overstate the ability of the index to describe the process of globalization.

There is not much discussion of missing data in this paper, despite some of the variables included reducing the amount of observations significantly. Finally, the author does not also include a more widely used globalization index such as the KOF to demonstrate external validity of the result.

However, this quality assessment is focused on the internal validity of studies, and aside from the issues with international representativeness of the components that make up the MGI and in some of the reduced panels (i.e. when including some of the confounding variables) no issues were detected.

Domain 2: Quality associated with data approach and analysis method
Judgement: Medium quality

Justification: there was no accounting for clustering in the study. Individual country differences were not incorporated, dummy variables for country not included and the methodology selected did not account for unobserved endogeneity. The authors extensively controlled for confounders, and presented a discussion of the confounders they did not include with justification. Further, a table of included control variables was included in the main text with official definitions, sample size and source.

It was mentioned in the methods section that the assumptions associated with both analysis methodologies were satisfied (half way down page 6, underneath table 3). This was expanded on in note 4, and the approach was reasonable.

Overall, the models they use were robust, but did not take some important factors into account. Thus, the domain could not score high quality.

Domain 3: quality in presentation of results
Judgement: medium quality only with respect to this review

Justification: in this review, we were interested in international trade or FDI, which were both included in the economic domain of the MGI. The model that used this domain was bivariate and therefore did not control for confounders (stated just above table 6 in the text). This raised questions about the reasons for presenting the aggregated index after controlling for confounders, and the disaggregated one before controlling.

In the context of this review, therefore, this domain must score medium quality.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: High quality

Justification: there was extensive discussion of each final model, and some discussion of the disaggregated models using each breakdown of the MGI. Although there was some risk of affecting study results from the analysis itself, the interpretation of the results they had did not reduce quality of the study. One minor point was that different control variables were presented in the 3 tables for mortality measures. It was a little unclear whether different control variables were used in each of them.

Domain 5: Other risks of bias
Judgement: N/A Justification:

A.5.14 Moore 2006

Non-trial quality assessment Fill-in sheet

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: The health of nations in a global context: Trade, global stratification, and infant mortality rates

Overall score: High quality

Overall justification: The authors used their own classification of world system role and these were different to the literature on the topic they referred to. The quality assessment was concerned with internal validity, however. Within the study itself, quality was high.

Domain 1: Quality from the data
Judgement: High quality

Justification: The authors conducted an extensive discussion of data quality. This did not include a discussion on external validity, but focused on the study itself. The panel of countries used was large and there was also a discussion of missing or low quality data. The authors addressed this by excluding incomplete countries from the analysis and avoiding poor data sources (116 remain from the original 128 and are listed at the bottom of page 173).

Overall the quality of the study was high with respect to data.

Domain 2: Quality associated with data approach and analysis method
Judgement: High quality Justification: The clustering of countries was on a role-level rather than a national level, and this was incorporated into the model via dummy variables. A range of control variables were also used.

The methodology was an OLS based log-log model, which accounted for non-normal distributions in the data.

Overall the methodological approach was applicable to this dataset, and the treatment of data was reasonable. The study therefore scored a high quality in this domain.

Domain 3: quality in presentation of results
Judgement: High quality

Justification: the authors were very clear when excluding variables from the analysis, and there was no evidence that any important results were omitted from the study.

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: High quality

Justification: Incremental F tests were used to indicate whether the addition of world systems role increased the R^2 of the OLS model significantly. A judgement in the study was that the insignificance of trade as a % of GDP when including world system role was an important result, but the reason for this was not thoroughly explained.

Further, as periphery 1 countries were highly dependent on international trade, trade as a % of GDP must be highly correlated with periphery 1. In order to avoid biasing the study, another model removing one or the other, using an interaction term or using an instrument to remove endogeneity would have been preferable. However, for the study they conducted, with the focus being on roles, this was unlikely to significantly bias the result. The score for quality was therefore high, since no serious limitations in relation to domain 4 were detected.

Domain 5: Other risks of bias
Judgement: high quality Justification: The authors did not compare their own classification of world system role to other studies. Without significant knowledge of that literature, it was necessary to highlight the issue, but it was not likely to affect the results of the whole study.

A.5.15 Owen 2007

Non-trial quality assessment Fill-in sheet:

Please use the following sheets to justify the decision you make for each paper considered in the quality assessment process. Please keep justifications concise, and describe only the reasoning for quality assessment.

Paper title: was trade good for your health?

Domain 1: Quality from the data

Judgement: High quality

Justification: The authors discussed the merits of the data they elected to utilise. However, there appeared to be a lack of discussion on data related weakness. The panel included 219 countries over the period 1960-1995 and had relatively complete data. Although data weakness was not discussed at length, the overall score for domain one was high quality.

Domain 2: Quality associated with data approach and analysis method
Judgement: High quality

Justification:

There was an emphasis on the long term relationship between trade and health because the data was at 5 year intervals.

Authors went on to describe the high variance in their key variable (openness to trade) across countries. They adjusted for this by introducing various openness measures as a sensitivity analysis.

A range of control variables were also used to account for confounding, including lagged dependant variables. Although a correlelogram was not provided, interrelationships between select variables were described descriptively. Overall the data approach was judged to be reasonable.

The statistical methodology was fixed effects estimation. The authors do not appear to have controlled for time variant characteristics in their primary analysis. However, this was following testing using lagged models to check for time variant characteristics, which revealed that their primary result was robust to them. Hausman tests were used, which indicated superiority of using fixed effects estimation also. Overall this was a model use of fixed effects estimation, with the inclusion of thorough robustness testing.

Domain 3: quality in presentation of results
Judgement: High quality

Justification: There was no evidence that any results were omitted

Domain 4: Quality from post estimation testing and analysis interpretation
Judgement: High quality

Justification: Each result in the main analysis was discussed with reference to each relevant robustness test, and each of the different trade openness measures were considered in equal weight. The inferences and conclusions weighed up all of the results without a noticeable preference or selectivity.

Considerable amounts of sensitivity analysis were included in the post estimation testing alongside testing for time-variant characteristics and reverse causality. In the one case where reverse causality was detected, this was reported and discussed in the main discussion. However, the potential endogeneity caused in the main model by the reverse-causal relationship between pharmaceutical goods, their relative price and life expectancy was not accounted for through use of an instrument or other means (e.g. attempting to omit medical imports/exports from the panel). This was judged to be of minor importance considering the extent of the robustness testing in the article.

Overall domain 4 scored high quality.

Domain 5: Other risks of bias
Judgement: N/A
Justification: N/A

A.5.16 Gerring 2008

Paper title: Do neoliberal economic policies kill or save lives?

Domain 1: Quality from the data

Judgement: High quality

Justification: The article utilises a large panel dataset including more than 100 countries, over a large time span. The data is considered carefully, and caveats to the analysis are acknowledged throughout the work. As an international panel study, this is the highest quality available evidence (and consideration of th evidence).

Domain 2: Quality associated with data approach and analysis method

Judgement: High quality

Justification: Country fixed effects are used, the explanatory variables lagged and the selection of controls, including a time-trend appears to be appropriate. Lagging of the explanatory variables to some extent takes endogeneity between the dependent variable and the explanatory variable into account, yet contemporaneous relationships between the explanatory variables could lead to some moderation effect on the associations. However, overall, the approach is well justified, and limitations are clearly discussed throughout. Consequently, the quality of the analysis approach and data treatment is high in this case.

Domain 3: quality in presentation of results

Judgement: High quality

Justification: Thorough discussion throughout the results and discussion sections. Discussion of spurious associations, and clear descriptions of meaning behind results leads to this domain being scored highly.

Domain 4: Quality from post estimation testing and analysis interpretation

Judgement: High quality

Justification: Sensitivity analysis is conducted through introducing additional controls or stratified sampling, and the results appear to be somewhat consistent. The authors argue that this pertains to some robustness of their findings. Overall this is a strength of the study.

Domain 5: Other risks of bias

Judgement: N/A
Justification: N/A

APPENDIX B

Supplementary materials for Chapter 3

Table B.1: *List of Countries Included*

Afghanistan	Ghana	Mongolia	Thailand
Albania	Gambia, The	Mozambique	Tajikistan
Armenia	Guatemala	Mauritania	Tonga
Burundi	Honduras	Mauritius	Tunisia
Benin	Haiti	Malawi	Turkey
Bangladesh	Indonesia	Malaysia	Tanzania
Bulgaria	India	Namibia	Uganda
Belize	Iran, Islamic Rep.	Niger	Ukraine
Bolivia	Iraq	Nepal	Vietnam
Brazil	Jamaica	Pakistan	Yemen, Rep.
Botswana	Jordan	Panama	South Africa
Central African Republic	Kazakhstan	Peru	Zambia
China	Kenya	Philippines	Syrian Arab Republic
Cote d'Ivoire	Kyrgyz Republic	Papua New Guinea	Zimbabwe
Cameroon	Cambodia	Paraguay	
Congo, Rep.	Lao PDR	Romania	
Colombia	Liberia	Rwanda	
Costa Rica	Sri Lanka	Sudan	
Dominican Republic	Lesotho	Senegal	
Algeria	Morocco	Sierra Leone	
Ecuador	Moldova	El Salvador	
Egypt, Arab Rep.	Maldives	Serbia	
Fiji	Mexico	Swaziland	
Gabon	Mali	Togo	

Table B.2: *List of countries included in sectoral analysis*

Bolivia	Nicaragua
Costa Rica	Nepal
China[a]	Pakistan
Dominican Republic	Peru
Ecuador	Philippines
Egypt, Arab Rep.	Papua New Guinea
Guyana	Paraguay
Honduras	El Salvador
Iran, Islamic Rep.	Thailand
Jordan	Tunisia
Kenya	Turkey
Sri Lanka	Tanzania
Morocco	Uganda
Mexico	VietNam
Mongolia	Zambia
Mozambique	

[a] *China data is from National Bureau of statistics of China (2014)*

Table B.3: *IVFE Models of FDI and Life Expectancy Using Alternative Measures of Education and Institutional Quality*

Model Number	**(A 3.1)**		**(A 3.3)**		**(A 3.3)**		**(A 3.4)**	
Alternate Variable	**Education**		**Capital formation**		**Capital formation**		**sd(ex rate)**	
Variables	**Coef.**	**P-value**	**Coef.**	**P-value**	**Coef.**	**P-value**	**Coef.**	**P-value**
FDI inflows (% GDP)	0.018***	(<.000)	0.014***	(<.000)	0.013***	(<.000)	0.007	-0.304
Years of Schooling			0.049***	(<.000)	0.047***	(<.000)	0.045***	(<.000)
Years of Schooling, Squared			-0.004***	(<.000)	-0.004***	(<.000)	-0.004***	(<.000)
Enrolment, % population	0.010***	(<.000)						
Civil Liberties Index	0.003	-0.182			0.003	-0.14	0.001	-0.866
Political rights index			-0.002	-0.19				
ln(GDPPC)	0.005	-0.668	0.006	-0.727	0.005	-0.77	0.01	-0.469
Urban Population	0	-0.505	0.001*	-0.1	0.001	-0.114	0.001*	-0.056
No. of Obervations	2697		3035		2975		3055	
No. of Countries	115		85		85		87	
F-stat (1st stage)	10.42		14.3		20.86		4.744	

*Notes: P-values are heteroskedasticity robust; *** p<0.01, ** p<0.05, * p<0.1*

APPENDIX C

Supplementary materials for Chapter 4

Table C.1: *Variables used to calculate asset scores for Chapter 4*

Variable	Obs.	Mean	S.D.	Min	Max
Household Electronics					
Radio	34965	0.39	0.32	0	2.5
Fridge	34965	0.44	0.37	0	1.6
TV	34965	0.68	0.29	0	1
Mobile Phone	34965	0.67	0.35	0	1
Washing Machine	34965	0.57	0.38	0	1
Camera	34965	0.14	0.27	0	1
Microwave	34965	0.15	0.28	0	1
Computer	34965	0.16	0.27	0	2.3
Vehicles					
Bicycle	34965	0.67	0.36	0	5
Motorbike	34965	0.2	0.27	0	9
Car	34965	0.05	0.18	0	9
Home assets					
Home ownership	34965	0.61	0.28	0	1
Air conditioning	34965	0.18	0.29	0	1
Electric fan	34965	0.08	0.19	0	5
Water from a water pump	34965	0.75	0.32	0	1

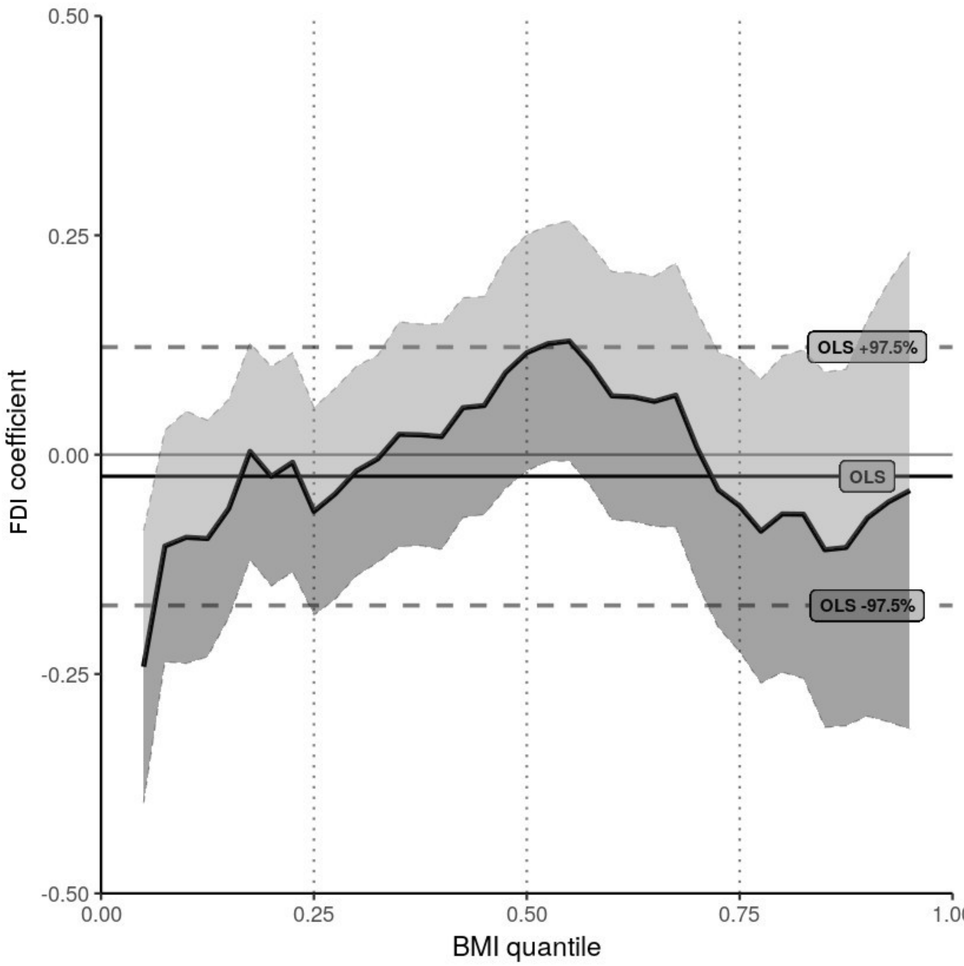


Figure C.1: *Coefficient for regional FDI in association with BMI from multiple quantile regressions*

Table C.2: *Unique observations by region and wave included in Chapter 4*

Region	1993	1997	2000	2004	2006	2009	2011
Guangxi	977	998	1016	1132	1131	963	956
Guizhou	894	1143	1059	1057	1044	947	874
Heilongjiang	0	830	936	991	942	865	794
Henan	740	844	832	929	850	930	810
Hubei	941	927	910	941	850	877	847
Hunan	928	893	979	974	1065	955	876
Jiangsu	794	938	1019	1065	989	974	815
Liaoning	597	0	920	1011	995	833	775
Shandong	696	790	892	980	1059	912	818

Table C.3: *Observations, individuals and households included in the estimation sample, by region of China*

Region	observations	individuals	households
Guangxi	7173	2015	570
Guizhou	7018	1979	576
Heilongjiang	5358	1443	537
Henan	5935	1820	548
Hubei	6293	1721	546
Hunan	6670	1844	569
Jiangsu	6594	1732	547
Liaoning	5131	1588	563
Shandong	6147	1683	534

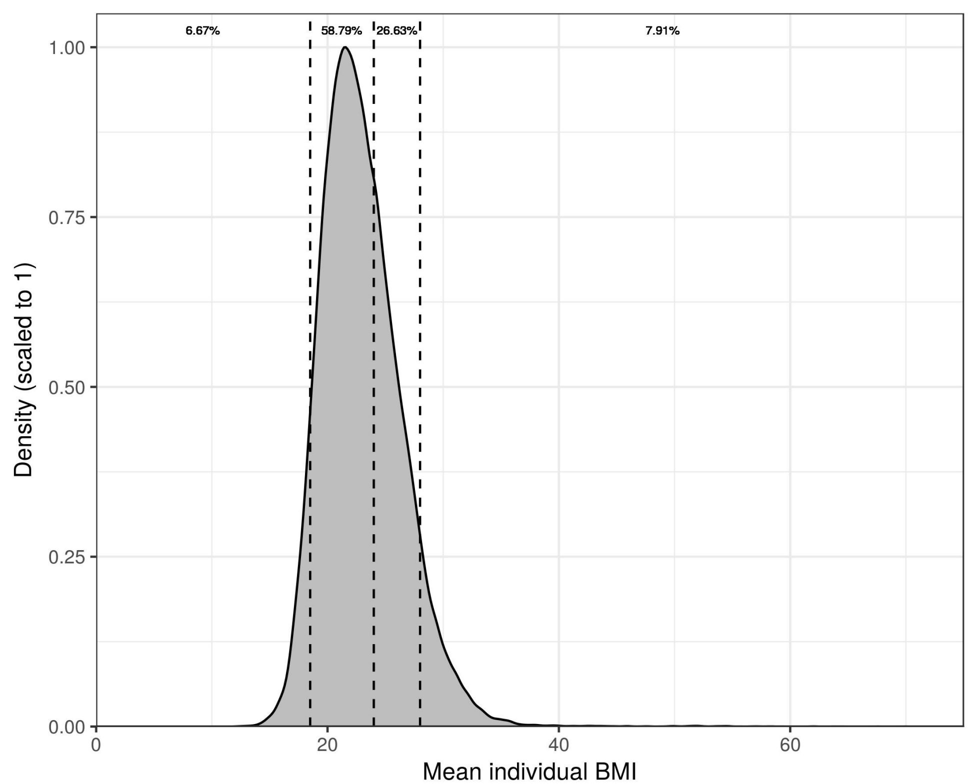


Figure C.2: *BMI in Chinese adults 1993-2011*

APPENDIX D

Supplementary materials for Chapter 5

Table D.1: *Descriptive statisics for the variables included in the principal component analysis of asset-wealth in Russian households*

Variables	n	Mean (%)	S.D.	Min	Max
Owns an Odach	29455	19.03%	0.39	0	1
Owns Vehicle	29455	41.75%	0.49	0	1
Owns colour TV	29455	97.52%	0.16	0	1
Owns Computer	29455	62.13%	0.49	0	1
Owns refrigerator	29455	52.51%	0.5	0	1
Owns a VCR	29455	23.00%	0.42	0	1
Owns a washing machine	29455	74.08%	0.44	0	1
Has hot and cold water	29455	88.22%	0.32	0	1
Owns home, rents home or lives in a domatory	29455	287.90%	0.39	1	3

Table D.2: *Mean WF in the 33 regions included in the Chapter 5 analysis*

Variables	Mean (%)	S.D.	Min	Max
Altai Republic	3.6	0.36	3.02	3.96
Altai Territory	4.76	1.33	3.48	6.91
Amur Region	14.11	2.51	11.56	18.5
Chelyabinsk Region	9.57	1.02	8.6	10.99
Chuvash Republic	9.06	0.46	8.56	9.78
Kabardino Balkar Republic	4.13	0.32	3.82	4.54
Kaluga Region	20.62	0.81	19.55	21.69
Khanty Mansi Autonomous Area	4.49	0.02	4.47	4.51
Krasnodar Territory	7.48	0.96	6.01	8.7
Krasnoyarsk Territory	13.91	10.89	6.72	32.07
Kurgan Region	5.61	0.8	4.96	6.89
Leningrad Region	29.34	4.47	24.72	36.67
Lipetsk Region	19.98	2.12	16.46	22.43
Moscow	48.44	8.59	43.07	65.48
Moscow Region	49.25	9.16	43.06	65.47
Nizhny Novgorod Region	13.51	0.9	12.46	14.65
Orenburg Region	6.23	0.72	5.37	7.4
Penza Region	8.35	0.38	7.89	8.72
Perm Territory	9.78	0.32	9.42	10.18
Primorye Territory	5.18	0.8	4.34	6.5
Republic of Komi	8.37	0.28	8.07	8.71
Republic of Tatarstan	8.46	0.34	8.03	8.97
Rostov Region	7.55	0.51	6.83	8.31
Saint Petersburg	28.76	1.43	26.52	30.43
Saratov Region	7.09	0.5	6.63	7.82
Smolensk Region	10.75	1.91	9.05	13.66
Stavropol Territory	5.37	0.79	4.61	6.69
Tambov Region	9.85	0.63	9.13	10.85
Tomsk Region	7.82	1.59	6.28	10.6
Tula Region	18.12	2.64	14.44	20.6
Tver Region	14.61	1	13.43	16.08
Udmurt Republic	10.98	1.14	8.99	11.91
Volgograd Region	6.64	0.43	5.99	7.22

Table D.3: *Descriptive statistics for sample of Russian men used in Chapter 5*

Variables	**n**	**Mean (%)**	**S.D.**	**Min**	**Max**
Outcomes					
Smoking prevalence	23386	53.32%	-	-	-
Cigarettes per day among smokers	12470	17.48	8.11	1	80
Individual covariates					
Age	23386	43.53	16.4	18	100
Non-Russian	3607	15.42%	-	-	-
PGT	1590	6.80%	-	-	-
Rural	6595	28.20%	-	-	-
Unemployed	7953	34.01%	-	-	-
Secondary	3258	13.93%	-	-	-
Vocational	13263	56.71%	-	-	-
University or higher	5250	22.45%	-	-	-
Believer	17499	74.83%	-	-	-
Non-believer	5145	22.00%	-	-	-
Not married	8887	38.00%	-	-	-

Table D.4: *Descriptive statistics for sample of Russian women used in Chapter 5*

Variables	n	Mean (%)	S.D.	Min	Max
Outcomes					
Smoking prevalence	32588	14.13%	-	-	-
Cigarettes per day among smokers	4606	11.86	6.68	1	80
Individual covariates					
Age	32588	48.22	18.3	18	101
Non-Russian	4503	13.82%	-	-	-
PGT	2208	6.78%	-	-	-
Rural	8615	26.44%	-	-	-
Unemployed	15087	46.30%	-	-	-
Secondary	4373	13.42%	-	-	-
Vocational	15655	48.04%	-	-	-
University or higher	8997	27.61%	-	-	-
Believer	29611	90.86%	-	-	-
Non-believer	2670	8.19%	-	-	-
Not married	17601	54.01%	-	-	-

D.1 Search terms for Smoking determinants

1. Smoking
2. Russia
3. Determinant

These search terms were applied in SCOPUS, which resulted in 46 results. These 46 results were abstract screened to establish relevance to Chapter 5. This process was also supplemented through searching of grey literature and the bibliographies of the studies as they were being reviewed for section 5.2.5.

D.2 Equation for marginal effect for Chapter 5

$$\frac{\Delta E[y|\mathbf{x}^{\tau}]}{\Delta x_j} = \Delta x_j(1 - e^{(\Delta x_j \beta_j)}) \times 100 \tag{D.1}$$

D.3 Net FDI inflows to Russia over time

Figure D.1: *Net FDI inflows to Russia, 1992-2016, % of GDP*

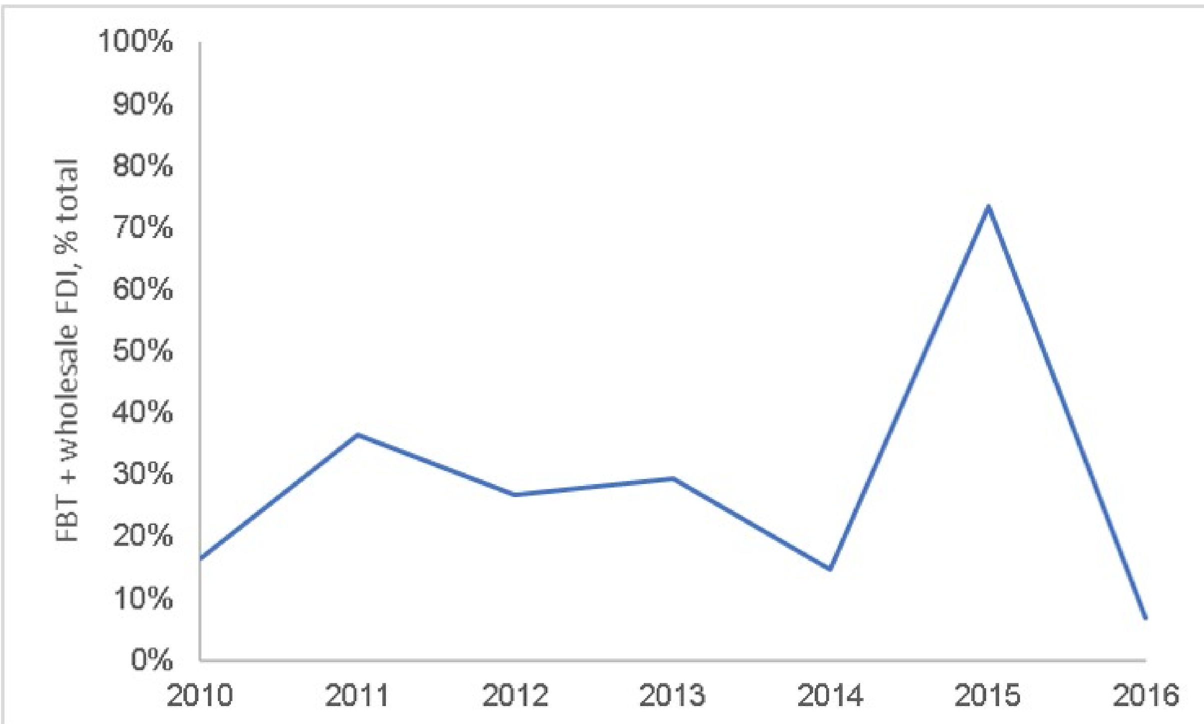


Figure D.2: *Net food, beverage, tobacco and wholesale trade FDI to Russia as a % of total*
Source: `http://www.cbr.ru/eng/statistics/credit_statistics/direct_investment/08e-dir_inv.xlsx`