Department of Economics

Essays in Economic Development

Graham Mott

Thesis submitted for assessment with a view to obtaining the degree of
Doctor of Economics of the European University Institute

Florence, November 2010

EUROPEAN UNIVERSITY INSTITUTE
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European University Institute
DOI: 10.2870/22962

DEDICATION

To my Mother, who continues to make all things possible.

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ACKNOWLEDGMENTS

In many theses it is stated that the document in question would not have come into existence without a throng of people supporting, aiding and contributing to the work of the author. It seems in many cases that this serves only as an attempt to further ingratiate the author to their peers and superiors and may not necessarily hold the truth it purports. In my case however there are a great number of people who have, both directly and indirectly, supported and contributed to make my life in Florence and the completion of this thesis possible.

Over the years that I have lived in Florence there has been a collection of carers and assistants who have made my daily life possible. To date this entourage has comprised Angela, Amanda, Nicolai, Lachlan, Brendan, Sarah, Louisa, Nikki, Ollie, Will, Becca, Rob, Zsofi and Paul. Naturally, some are considered or remembered with more fondness than others but I am grateful to the assistance of all those people who have enabled me to continue a relatively stable and functional existence. Especially, I would thank Jonathan Leupert for his unfaltering ability and willingness to step in, not only for what he terms *working holidays* but also at times of crisis and at incredibly short notice.

On the academic side of life, my supervisor Rick Van der Ploeg has been a great support. He continues to astound me with his ability to condense Economics chat into ten minutes of an otherwise extremely entertaining and interesting dinner. He is remarkably quick when called upon for assistance and has remained a continual source of encouragement and advice. I thank Omar Licandro for his time and patience regarding numerous academic projects and for his candid conversations regarding an academic life. To Fernando Vega-Redondo I am thankful for the opportunity of being a TA for such an interesting and engaging course. To the administrative staff of the Economics Department I extend my warmest gratitude, in particular to Jessica Spataro and Lucia Vigna. Among the innumerable tasks I have asked of them both (and have always been graciously and very patiently obliged), special mention must surely go to the titanic, 16 month struggle with the Motorizzazione *in*Civile that may unfortunately scar Lucia for years to come. Life in Florence would have been considerably more difficult without the aid of Jessica and Lucia.

Lastly, special mentions go to Rory O'Farrell for his advice on any manly situation, to Nicolas Serrano-Velarde, the Mesrine of grapes, to Aurora Ascione for recommending the

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best wine shop in Florence and to Renato Faccini for teaching me all the best Italian words.

To all these people, I am truly very grateful.

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Part I

Introduction

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The difficulties and obstacles faced by the poorer nations of the global economy on the path to development are extremely diverse. A thesis that aims to address some of the more interesting facets of development is itself likely to be wide ranging and so it proves with this dissertation. This thesis is a collection of four chapters which consider an array of pertinent questions regarding developing nations. Although there is not a singular issue or topic that connects the components of this thesis, each chapter addresses, in this author's opinion, at least one of the more interesting issues of economic development. This thesis is neither wholly empirical or theoretical, macro or micro and instead maybe viewed as an eclectic mix of approaches and ideas that go some way to representing the challenges faced by the world's least developed economies. In the following paragraphs, a brief overview of each of the four chapters is given.

The first chapter of this thesis, *A Further Unbundling of Institutions: An Application to Volatility and the Implications for Institutional Reform*, explores the varying effects of aspects of institutional quality on different categories of economic volatility. In particular, the institutional bundle is decomposed in a similar, yet more extensive, manner to Acemoglu, Johnson and Robinson (2003) and the resulting indicators of institutional quality are used to explain cross-country differences in the volatility of GDP growth, consumption, investment and trade. Uniquely, this paper introduces an exogenous instrument for political aspects of the institutional bundle, making use the POLCON index of political fractionalisation to include a relative political constraints variable to the model. The results show that each type of volatility is affected by differing combinations of the institutional quality instruments and thus, implies that policy which is concerned with dampening a specific type of economic volatility should specifically target a given proportion of the institutional bundle. Furthermore, it should become apparent that it should not longer be acceptable in future works to use broad, subjective variables to represent institutional quality.

The second chapter, *Diversification in Primary Commodity Production: A Path to Self-Insurance and Development*, investigates the theory behind the largely failed policy of import substitution industrialisation and in particular, that the issue of long term decline in real commodity prices relative to manufactures is secondary to that of primary commodity price volatility for countries at the lower end of the development scale. We forward a policy of diversification across production in the primary commodity sector within developing countries; specifically that this type of diversification can insulate developing economies from the effects of highly volatile primary commodity prices in a manner akin to modern portfolio theory and thus, promote growth and development. Furthermore, empirical results suggest

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that diversification may act as a substitute to financial development as a means to dampen terms of trade volatility in countries with poorly established economies.

The third chapter, *Sticks and Stones: A Theory of Point Resources and Appropriation*, extends the general equilibrium model of appropriation and production as presented in Grossman and Kim (1996), by including a parameter to represent the pointiness of the contested resource endowment. The effects of pointiness on appropriation and defence create non-linearities, resulting in a number of (non-monotonic) relationships between resource pointiness and conflict. It is demonstrated that appropriative equilibria may not necessarily be more socially costly in a non-aggressive equilibrium or that a non-aggressive equilibrium may not necessarily preserved the 'social ordering', despite an absence of appropriative activity. Further, the rich will only favour more secure claims to property if there would be no relatively 'cheap' targets created as a result of weaker security of claims. Likewise, the poor may not automatically favour weaker claims to property.

The fourth and final chapter, *The Kids Aren't Alright: Child Mortality and the Persistence of Child Labour*, extends the discrete time, overlapping generations model of Chakraborty and Das (2005). The model presented here includes a child survival function, where the rate of survival of a child is dependent on the healthcare expenditure of the young parent. It is demonstrated that the inclusion of this function reinforces the endogenous time preference mechanism outlined in Chakraborty and Das (2005) by increasing the cost of education and thus, future consumption. Inclusion of the child survival function thus reinforces *the prevalence and persistence of child labour*. Further, the paper elucidates on policy implications and makes algebraic corrections to the original paper.

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Part II

Essays in Economic Development

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CHAPTER 1

A FURTHER UNBUNDLING OF INSTITUTIONS

1.1 Introduction

The aim of this paper is to contribute to two areas of economic research which may currently be described as in vogue; the understanding of economic volatility as a barrier to long term growth and the breakdown of institutional bundle into component parts and effects. Recently, groups of collaborative authors (La Porta, Lopez-deSilanes, Shleifer and Vishny and Acemoglu, Johnson and Robinson) have shown the importance of rejecting subjective or indeed endogenous measures of institutional quality. This paper uses this body of work as a basis for an application to economic volatility. In particular, the work of Acemoglu, Johnson and Robinson (2003) is extended so that the institutional bundle is decomposed into four separate entities. Uniquely, one of these entities is a variable that represents contemporaneous institutional change in the political spectrum, a measure which is derived from the POLCON index of political fractionalization prevalent in the work of Henisz (2002, 2004).

It is only in the last decade or so that economic research has strongly suggested that economic volatility is detrimental to long term economic performance, especially in terms of GDP growth rates (see Ramey and Ramey (1995) for instance). As such, it would seem logical to try to understand the indirect role institutions play in promoting growth, insofar as 'high quality' institutions will serve the purpose of reducing economic volatility. On the role of institutions, North (1983) states:

Institutions provide the incentive structure of the economy and it is that structure, through its development, that determines the direction of the economy.

It is through this role that institutions not only determine the direction of the economy but also how steady the chosen economic path will be. Both historical (17th Century English Revolutions) and contemporary (Central Bank independence trends) instances of institutions fulfilling this role are highlighted within this paper. These examples serve to demonstrate, allegorically, that it is not only the direct effect of institutions on growth or GDP levels that is significant, but also the indirect effect, through the institutional effect on volatility, that can play an important role in determining economic outcomes.

The main objective of this paper is to be able to empirically investigate the relationship

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between institutions and economic volatility in this context. By decomposing the institutional bundle into economic, political, legal and cultural entities that are both objective and exogenous, it is therefore possible to use these variables in an econometric framework to explain varying types of economic volatility (specifically GDP growth volatility, consumption growth volatility, terms of trade volatility and foreign direct investment volatility are chosen). The consequences of doing this should be twofold: firstly, it should be observed that institutional variables will, of course, differ in their explanatory power for a given type of volatility and secondly, that institutional variable will differ in their explanatory power across types of volatility. In essence, it will be shown that differing (combinations of) aspects of the decomposed institutional bundle will be significant for explaining economic volatility and the identity of these significant aspects will depend on the type of volatility under scrutiny.

Perhaps on the outset, given these stated aims, it may be reasonable to hypothesise that volatility in variables such as GDP growth and consumption growth may be linked to political and economic factors, as can be seen in the following example of 17th Century institutional reform. Furthermore, volatility of variables that could be argued to reflect the relationship between a given country and a 'basket' of its trading partners, such as terms of trade or foreign direct investment levels, might be more significantly linked to variables representing the quality of the legal system or cultural constitution. Such variables may implicitly represent international accountability or trustworthiness. These issues shall be explored and possible explanations for any differences in institutional influence on volatility shall be discussed.

Summarising, this paper will be drawn towards two conclusions. Firstly, that it is no longer acceptable in economic literature, or indeed any kind of quantitative analysis, to use subjective, endogenous or generalised variables to represent institutions or institutional quality and secondly, that any form of institutional reform needs to be specifically tailored to a particular aspect of the institutional bundle, dependent upon the precise aspect of the economy the policy is ultimately designed to affect.

The rest of the paper is organised as follows. Section 2 discusses background literature concerning volatility, section 3 discusses background literature concerning institutions, section 4 deals with empirical implications, section 5 presents results and section 6 concludes.

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1.2 Literature

1.2.1 An Overview of Volatility

The literature concerning the relationship between institutional quality and macroeconomic volatility is scarce and thus, a key motivation for this paper. In the following section, the importance of volatility as a variable of interest is outlined, as is the theoretical relationship between institutions and volatility.

It may be expected that the common belief concerning this relationship would be that higher institutional quality was beneficial in the sense that economic volatility would be dampened, thus promoting higher levels of growth. This type of relationship can be illustrated with both historical and contemporary examples.

In pre-16th century England, the Monarchy held significant powers of expropriation and could raise taxes or redistribute assets in almost any manner they saw fit. Due to the uncertainty and volatility of taxation and ownership, institutions during these times failed to provide the necessary incentives for economic agents to invest in land, technology or capital, either physical or human, and failed to foster economic growth. However, the expansion of trans-Atlantic trade and changes in the English land markets during the 16th and 17th greatly empowered certain groups in society, namely merchants and landowners. These groups were twice able to overthrow the Stuart Monarchy during the 17th century (English Civil War, 1642-1649, and the Glorious Revolution, 1688) and subsequent institutional reforms granted economic rights and political power to a much wider group of agents than had previously been experienced. Arguably, it was these institutional changes that laid the foundations of the Industrial Revolution to follow.

A more contemporary example of institutional quality affecting economic volatility is the trend for central bank independence. This is seen as important factor in taking economic decisions away from those who gain political or personally. If politicians are able to manipulate economic policy, they may be able to engineer favourable economic outcomes at political sensitive times, especially during pre-election periods. This results in higher inflationary volatility and political business cycles (Alesina, 1989). Another means of limiting the actions of politicians, linked with the idea of central bank independence, is to create a system with a greater separation of powers and therefore, more checks and balances of the policymakers.

Although there is some uncertainty as to the exact relationship between volatility and growth, recent papers, both empirical and theoretical, have suggested that there is indeed a negative correlation between the two.

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Ramey and Ramey (1995) shows that countries with larger fluctuations in GDP growth will tend to have lower average GDP growth, a relationship that is robust in the inclusion of standard control variables. In addition, government spending induced volatility is negatively associated with growth even when time and country fixed effects are controlled for. The literature suggests a number of reasons why volatility is detrimental to economic performance. From a household perspective, risk-averse households save less when returns to capital are volatile (Rosenwzeig and Wolpin, 1993) and similarly, Pindyck (1991) argues that if investment contains irreversibilities, i.e. sunk costs, then increased volatility will necessarily lower investment. Furthermore, errors due to uncertainty-induced planning are costly for firms (Ramey and Ramey, 1991), as is the need to move factors of production between sectors in the need to rectify such errors (Bertola 1994, Dixit and Rob, 1994).

Koren and Tenreyro (2006) have sought to decompose the volatility of GDP growth into component parts in work comparable to an accounting exercise. Using this breakdown of volatility, the question of why poor countries experience much greater volatility of GDP growth in comparison to rich ones is addressed. Three explanations are offered and developed for the cause of this difference; poor countries in comparison specialize in fewer, more inherently volatile sectors, poor countries experience more frequent and severe macroeconomic shocks and that a higher correlation exists in poor countries between macroeconomic fluctuations and the shocks which specifically affect the sectors those countries specialize in. Whilst this related work is readily acknowledged, the approach in this paper is more concerned with volatility of some key macroeconomic variables and with the primary focus of investigating the hypothesised role of institutions as dampeners of said volatility. The relationships between institutional factors and the decomposition of volatility, or indeed of its microfoundations, are left as an area for future research.

It has not only been the link between the volatility of GDP growth and growth itself which has been the focus of research. Literature in Development Economics, particularly, has been keen to explore the relationship between terms of trade volatility and GDP growth. Blattman et al (2007) finds that countries that experience more volatile terms of trade also have relatively lower levels of growth (although in the models presented, terms of trade volatilities vary between countries due to national commodity specialization where commodities have heterogeneous price volatilities[1]). Mendoza (1997) finds the same result using a sample of forty countries, both industrialised and developing, for the period 1970-1991 and Turnovsky and Chattopadhyay (2003) find strong evidence of the same negative correlation

[1]However, further research may highlight that commodity price volatilities may be greatly affected by institutional quality, especially in the cases of countries with more mobile resource bases.

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in a sample of 61 developing countries, between 1975 and 1992. Therefore, it seems that in any paper aiming to explore the issue of the effect of institutional quality on volatility, and thus indirectly GDP growth, terms of trade volatility should feature prominently.

The measures of economic volatility utilised in this paper will be the following: the volatility of GDP growth, the volatility of consumption growth, terms of trade volatility and the volatility of the logarithm of net foreign direct investment. The intuition behind the use of these measures as dependent variables in this paper is that they are key, headline indicators of economic development and performance. Also, statistics on these variables are available for a large number of countries, over a wide time period and they are measured in the same manner. This is not the case for other measures of volatility, especially with regards to measurement units and scales.

The fundamental hypothesis of this paper is that the explanatory significance of different institutions aspects will vary according to the type of volatility measured. For example, legal institutions may be expected to play a more important role in explaining investment volatility than cultural institutions per se. In order to test this, the volatility of four macroeconomic variables has been chosen, as stated above. The data for these variables comes from the *World Development Indicators*[2] and the *Penn World Tables*.

Below, the role and choice of institutional instruments is discussed.

1.2.2 An Overview of Institutions

It is only recently that economists have begun to look seriously at the empirics behind institutional quality and economic performance. In this section, some of this work is highlighted and the case for institutions as a topic of research is furthered.

Given the events in the Far East of 1997 it is of no surprise that much of this work has focused the role of institutions with regard to financial liberalisations. Chinn and Ito (2002) proposes that financial systems with higher degrees of development in legal institutions, on average, benefit more from financial liberalisation than those with lower levels[3]. At the time of the East Asian crisis, commentators questioned the institutional framework of the affected countries. Bhagwati (1997) criticizes the U.S. Treasury and IMF for rushing too many countries into liberalising their capital markets without due consideration to whether domestic market regulation was sufficient to cope with the rapid changes. Furthermore,

[2]Henceforth WDI.

[3]There is a need to reach a threshold level of institutional development before it is seen that a higher level of financial openness leads to equity market development. Indeed, if the threshold is not reached then increased openness can be harmful to equity market development.

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Chinn and Ito (2002) also highlight the need to specify the particular significance of different institutional aspects. The results show that it is general legal systems and non-financial specific institutions that are crucial for benefiting from increased openness.

A point that should be readily addressed is that institutional quality variables that are used in much of the empirical literature have a tendency to be endogenous. For example, it is easy to observe that countries which have high levels of GDP are more likely to have better quality institutions and it is easy to map this relationship. However, difficulty arises when determining causality as not only will better quality institutions contribute to the achievement of higher levels of GDP but richer countries will simultaneously be able to afford either better quality institutions or the reform of pre-existing, poor quality institutions. Therefore, any correlation between contemporary institutional quality variables and economic outcomes is likely to be capturing a significant degree of reverse causality.

Whilst many papers have largely failed to recognise the importance of endogeneity in specifying regressions of GDP and institutional quality, a body of work by Acemoglu, Johnson and Robinson (AJR) has gone some way to addressing this particular issue. Their work uses mortality rates of European settlers during the 1600's as an instrument for contemporaneous institutional quality. It is proposed that there existed two different types of colony, extractive states (e.g. Belgian Congo) and neo-Europes (Australia, Canada etc). Coloniser strategy depended on settlement feasibility; where the disease environment was unfavourable then the probability of Neo-Europe creation was low and extractive states more likely prevailed. The observation that the early framework of colonial institutions in essence reflected the wants of settlers is supported by earlier research, such as Denoon (1983).

It is argued that these Colonial states and institutions continue to persist, even after independence. Amongst the reasons cited for this persistence are that colonisers have previously incurred a large sunk cost to found institutions and little incentive for costly reform may exist, especially if gains from extractive institutions are shared amongst a small elite. Moreover, influential agents may have made sunk investments which are complimentary to certain institutional types. However, even though there are long periods of institutional persistence, it must be recognised that in the last three decades, the institutional landscape has changed significantly, especially in the political spectrum. Empirical work must have the capabilities of capturing these more recent changes.

Settler mortality serves as a good instrument in the respect that it should have no effect on current output other than its effect on institutions. The majority of European settler deaths were caused by either yellow fever or malaria and had little effect on the indigenous adults. Therefore, diseases are unlikely to be a significant reason as to why many African

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and Asian countries are poor today.

The work of AJR, the use of institutional instruments and empirical pitfalls are further expanded upon in the following section.

1.3 Empirics

1.3.1 Empirical Hazards

When dealing with the institutional quality and volatility, it could be argued that any correlation between the two is generated mainly by causality from the former and reverse causality does not have the same significance, or pose the same problems, as in the example above. Good institutions theoretically have directly positive effects on both volatility and GDP levels, as highlighted above, but also have an indirect effect on GDP levels with volatility acting as a medium. Although it can be said that richer countries can afford to create better institutions or reform those which are poor, there seems to be no plausible theoretical argument in the literature as to why volatility directly affects institutional quality.

It is not only the direction of causality that is of concern with variables of institutional quality. Often datasets, such as the International Country Risk Guide (ICRG) or Polity IV, contain contemporary measures of institutional quality that are purely subjective, such as level of democracy, bureaucratic quality, corruption, autocracy etc. In the main, this type of variable will create two problems. Firstly, it is reasonable to expect that variables of a subjective manner are exposed to a significant degree of measurement error and may not properly reflect the true state of outcomes they represented. Thus any regression analysis will be adversely affected by the relationship between the omitted characteristics on policy/institutions and economic outcomes. Secondly, any historical outcome of a subjective variable is most likely to be solely an ex-post, fitted observation and indeed, a lack of historically consistent information leads to endogeneity if current information or opinion is used to estimate historical outcomes. Measures that are affected in this manner can result in models having poor predictive power. Citing the East Asian crisis as an example, Henisz (2004) states:

Importantly, the correlation between these subjective measures and the true nature of the political institutions may breakdown precisely when correct measures would be most valuable.

Furthermore, previous empirical work on institutions commonly bundles many cultural, legal, political and financial facets together under a broad brush indicator or conversely, chooses to focus solely on the effect of one of facet. While it may greatly simplify the empirics of such work to focus on broad indicators, and indeed may enable equally broad statements

to be validated, there is a need to deconstruct these indicators to find out which types of institutions matter and how they can affect the volatility of different aspects of the economy. However, it is also equally important that empirical investigations focus on the institutional framework, so that any deconstruction does not overlook important institutional factors. Thus, in this paper, we aim to justify the use of a number of variables which simultaneously represent the effects of institutional quality on volatility, whilst also fulfilling requirements concerning independence and exogeneity. Below, the steps to achieve the separation of institutional effects are outlined.

As stated previously, institutions are the body of arrangements which constrain agents economically, politically, culturally and legally. If this is taken as the definition of institutions then each of these aspects much be addressed when looking at a decomposition of the institutional cluster. Key to the argument of this decomposition is the possibility that each of the four aspects may be represented by variables that can be deemed as exogenous and independence. The literature of political economy has touched upon this subject, for example Knack and Keefer (1995) argue that measures such as degree of democracy or political or civil liberties need not be correlated with the level of property rights. Indeed, it is easy to think of anecdotal examples where there is obviously a contrast in political and economic institutional qualities. At present, China has laws restricting freedom of speech, expression, religion and political choice yet has significantly better quality economic institutions and business is relatively free to proceed. On the other hand, Russia seems to uphold the institutions that China lacks but Russian economic institutions are of much poorer quality, frequent expropriation takes place at all levels and business progression is hindered by economic corruption. In between, the US may be heralded as an example of a nation of high quality institutions. It seems reasonable to accept, based on empirical, theoretical and anecdotal sources, that it is indeed possible to separate the institutional threads in this manner, given a set of correctly chosen instruments. This matter is discussed below.

1.3.2 Institutional Instruments

A challenge that is faced by all empirical work dealing with institutions is firstly to find variables or instruments which reflect institutional quality. In the most part, regressions dealing a contemporary measure of institutional quality suffer from some form of endogeneity. If variables for GDP, consumption, trade or investment were regressed on a measure such as stock market valuation, as an instrument for financial development, then the results of these regressions would certainly suffer from endogeneity. For example, higher investment would cause higher stock valuations and these higher valuations may act as signal of a

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healthy economy and encourage further investment. Therefore, the most key element of the "declustering" exercise is to find exogenous, independent instruments.

Some previous work has concentrated on the "declustering" of institutional variables and highlighted the varying influence of institutional aspects, as discussed above, on economic outcomes. La Porta, Lopez-deSilanes, Shleifer, and Vishny[4] (1997,1998) highlight the importance of colonizer identity and legal origins of current institution, in particular that former British colonies and common law countries fare better in terms of financial development. Rodrik (2000) suggests that democracies experience less volatility than non-democratic regimes. Also, Von Hayek (1960) argues that British common law tradition was superior to French civil law for general economic development.

In a recent paper, Acemoglu and Johnson (2003), efforts have been made to "unbundle" the institutional cluster. The aim of this exercise is to investigate the relative importance of contracting institutions, i.e. those which involve upholding private contracts, and property rights institutions, i.e. those which protect against government expropriation. The former can be measured by legal formalism, in particular by variables measuring the number of legal procedures needed to resolve a simple common case (Djankov, La Porta, Lopez-deSilanes, and Shleifer[5], 2003). The latter can be measured by variables for expropriation risk or constraints on the executive. Due to issues of endogeneity as outlined above, instruments are used to represent these institutions, namely settler mortality and population density in 1500 as an instrument for expropriation risk (see AJR 2002, 2003) and legal origin or coloniser identity as an instrument for legal formalisation (see DLLS, 2003 and LLSV, 1997, 1998). Of the countries sampled, those with greater political constraints and protection from expropriation have significantly higher incomes per capita; higher investment rates; a higher ratio of private sector credit to GDP and more developed stock markets. Conversely, those countries with greater legal formalism tend to have less developed stock markets, yet neither income per capita, the private credit to GDP ratio nor the rate of investment are impacted. These results maintain the theory that the different aspects of the institutional cluster should be considered when investigate the economic effects of institutions and that these different aspects have varying effects.

However, whilst an instrument has been used to solely represent the legal aspect of the institutional cluster, using either settler mortality or population density acts to instrument both for economic and political institutions simultaneously. Furthermore, by using solely historical instruments there is no scope for these results to reflect any of the institutional

[4]Henceforth, LLSV
[5]Henceforth, DLLS.

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changes that have been witnessed in the past few decades. This paper will endeavour to construct a variable that is exogenous and that also represents both the distinct political aspect of the institutional cluster and contemporary institutional changes.

In further support of including different institutional aspects, Stulz and Williamson (2003) use both religion and legal origin in regression analysis in order for two different aspects of the institutional landscape, cultural and legal, to be controlled for in an independent and exogenous manner. They find that legal origin is more important than religion in explaining equity holder protection laws, while the opposite is true for laws protecting creditors. Thus, cultural institutions can have significant explanatory power in regressions concerning legal outcomes. Indeed, instruments or variables used to represent any one of the four institutional aspects may have significant explanatory power with regards to an outcome of one of the other three aspects, in particular an outcome which may not necessarily be captured by the intended variable. Therefore, this is further support for the need to try and control for all aspects of the institutional make-up rather than just for particular effects.

As discussed previously, it is important not only to find exogenous instruments but also to represent the significant changes seen in the institutional framework over the past few decades. Whilst the use of these historical instruments is valid and has been justified, this approach fails to take into account any contemporary institutional changes or developments. In order for this to be accomplished in this paper, an instrument to represent contemporary political institutional change shall be used. The construction of this instrument is highlighted below.

1.3.3 Construction of the Political Instrument

In many cases in the literature, variables that are used to represent political constraints or outcomes suffer from one of the aforementioned problems, endogeneity, subjectivity, measurement error etc. Examples include a large majority of the variables in the Polity IV and ICRG datasets. However, there is little doubt that political constraints play an important role with regards to volatility, growth and development, both within and between nations. Countries with more checks and balances are less likely to allow the executive to alter policy for reasons other than those relating to the economy. Fatas and Mihov (2005) run regressions between institutions and policy, showing that political constraints matter more in rich countries than in poor. In addition, policy volatility has a larger negative effect for growth in poorer countries, thus supporting the hypothesis that investment is a channel through which policy volatility affects growth. As stated previously, there is also the need to represent contemporary institutional changes in an exogenous manner.

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Henisz (2002) sets out to find a link between an objective measure of political constraints and cross-national growth rate variation. The constructed variable, POLCON, is derived from a simple spatial model and relies on the number of independent veto points in the political system and the distribution of political preferences across and therein[6]. This measure is found to be statistically and economically significant in its impact on growth, when using OLS, 3SLS and GMM.

There are considerable differences between this variable and those which has been used previously to instrument for political constraints. Firstly, POLCON is an objective measure of constraints and thus does not suffer from as many problems with respect to subjectivity and measurement error. Secondly, this variable contains more information than previous measures. For example, South and East Asian countries score highly with regards to political institutional quality on the Polity IV and ICRG datasets but poorly on the POLCON scale[7], due to lack of veto points, strongly aligned and homogenous legislatures and subservient courts. The events of the East Asian Crisis may therefore go some way to validating the POLCON approach towards measuring political constraints.

In order, for this variable to be of use (at present it could be assumed that including it any regressions would introduce endogeneity into model) it will be modified so as to represent the existing political constraints at given time relative to the range of these constraints experienced over the total time series. Hence, the following is used to determine the new variable, relative constraint (RC):

$$RC_i = \frac{POLCON_i - POLCON_{MIN}}{POLCON_{MAX} - POLCON_{MIN}} \qquad RC_i \in [0,1]$$

This instrument measures the constraints in a political system present at any one time relative to the spread of constraints that has been experienced over the complete time series. This variable is not dependent on the total number of veto points in the same manner as the POLCON variable. Obviously, systems with a larger number of veto points allow for this variable to take a greater number of values, but those values will occur over the same span. Indeed, cross-country comparison is of the form:

Country A is more constrained, relative to its time span of political constraints, than Country B, relative to its own time span of political constraints.

As such, the total number of veto points and the problem of endogeneity occurring due to the inclusion of variables of exact political structure are no longer issues for significant

[6]For an explicit methodology on the construction of this variable, see Henisz (2002). For an overview, see Appendix 1.

[7]Low scores on the POLCON scale constitute poor constraints.

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concern. Furthermore, as this variable captures the changing level of relative political constraints it may also reflect contemporary institutional change within a political system. In essence, it could be said to be an instrument which represents political institutional circumstances. By including this instrument in later regressions, it would be hoped that a balance between historical and contemporary institutions will be reached, allowing for much of the cross-country variation in the volatility of key macroeconomic variables to be explained.

To summarize, this paper shall utilise; the variables of legal origin and religion, from LLSV (1997, 1998) and Stulz and Williamson (2003), to instrument for legal and cultural institutions respectively; the variable of settler mortality and/or population density in 1500, from AJ (2003), as an instrument for economic institutions and the newly constructed 'relative constraints' variable to instrument for political institutional change. Thus, instruments have been found for each aspect of the institutional bundle.

1.3.4 Robustness

There is a necessity to separate the effects of persistent institutional quality from the effects of country specific factors, otherwise regression analysis may be identifying the effects of socio-geographic factors such as latitude, access to the sea, weather, language etc. In essence, by including a set of endogenous control variables, this approach looks to filter out the effects of, in panel data terms, country specific fixed effects. Data for the control variables is obtained from WDI.

1.4 Results

Four measures of macroeconomic volatility have been used to investigate the differing effects of unique aspects of the institutional bundle; GDP growth volatility[8], private consumption growth volatility[9] volatility of the terms of trade[10], and the volatility of the logarithm of net FDI[11]. In each case, volatility is calculated as the standard deviation of the variable of interest, over a thirty five year period or to the extent that the data allows. It is acknowledged that volatility over this time period will change for each variable. For example, it should be expected that economic volatility would be much greater in the 1970's than at present. However, as this paper is only concerned with cross-country comparisons, the issue of variability within a country over time is not of concern, it is the differences in

[8]Source: Constructed from WDI.
[9]Source: Constructed from Penn World Tables.
[10]Source: Constructed from WDI.
[11]Source: Constructed from WDI.

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variability between countries that is of interest. Tables 1-4 show the results of OLS regression analysis carried out using the instruments for institutional quality and geographical controls previously outlined. When independently regressing instruments and volatility, the sample size varies in each case due to the unbalanced nature of the dataset, which can be attributed to the sourcing of data. Thus, regressions that include the Settler Mortality variable have a lower number of observations in comparison to others, as this is by far the smallest data series available.

In Table 1, it can be seen that legal origin, settler mortality and the Muslim religion are all significant when individually regressed with GDP growth volatility. Furthermore, when only the control variables are regressed with GDP growth volatility, it can be seen that only the variable for absolute latitude is significant, and is so at the 5% level. This coefficient is negative, as would be expected, signifying that a country further from the equator experiences lower GDP growth volatility. This tallies with contemporary observations of countries within the tropics experiencing poor economic outcomes and conditions.

Each of the coefficients associated with the significant variables is of the sign that might be expected considering previous research. The coefficient of settler mortality is positive and significant at the 1% level, suggesting in a given country a higher mortality rate amongst early European immigrants corresponds to higher volatility in present GDP growth. When GDP growth volatility is regressed upon each of the institutional instruments and the control variables, as in regression vi, it can be seen that this relationship persists albeit with a weaker level of significance, 10%. However, the significance of the French legal origin dummy does not persist from regressions ii to vi. In regression ii, the coefficient is positive and significant at the 5% level. This basic observation concurs with those found by Levine et al, in that a French legal system is detrimental to economic performance in developing countries in comparison to a British system. This relationship ceases to be significant in the larger regression.

With regards to religion, the coefficient of the variable for Muslims is significant at the one percent level, whereas the coefficients of the variables for Catholics and Protestants are insignificant. For an increase of one percentage point of Muslims as percentage of the population, GDP growth volatility increases by 0.02412 and thus, the greater the percentage of Muslims in the population, the more volatile is GDP growth, ceteris paribus. Again, as with the coefficient of legal origin, this relationship is no longer significant when all dependent variables are regressed together. This also seems to support previous observations, by and, that religion as a cultural institution has effects through aspects of the legal system, as both the legal system dummy and religious variables are insignificant in the broader regression.

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Table 1.1: Dependent Variable: GDP Volatility

	(1)	(2)	(3)	(4)	(5)
Settler Mort	0.618***				0.381*
	(0.154)				(0.202)
French LO		1.849**			0.281
		(0.719)			(0.599)
British LO		1.223			
		(0.744)			
Muslims			0.0241***		0.0129
			(0.00810)		(0.00993)
Catholics			0.000638		0.0119
			(0.00740)		(0.0103)
Protestants			-0.00445		0.0231
			(0.0111)		(0.0164)
POLCON				0.459	1.169**
				(0.512)	(0.580)
Latitude					-1.358
					(1.691)
Country Size					-0.131
					(0.0963)
Water/Land					-2.542
					(5.469)
Landlocked					0.00416
					(0.551)
Africa					0.517
					(0.571)
Constant	1.525**	3.066***	4.016***	3.809***	2.241
	(0.751)	(0.659)	(0.552)	(0.374)	(1.355)
Observations	67	108	108	97	62
R^2	0.199	0.064	0.153	0.008	0.354

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

DOI: 10.2870/22962

Whereas coefficients become less significant from the individual instrument regressions to the broader regression, this is not the case for the relative political constraints variable. In regression iv, the coefficient associated with this variable is insignificant, yet in the broader regression it is positive and significant at the 5% level. In regression vi, the coefficient signifies that countries who had relatively fewer political constraints in the past compared to the present day will suffer from higher GDP volatility those would had relatively constrained politically systems historically. This would support suggests that unconstrained leaders or political executives can have a detrimental effect on economic outcomes and checks and balances within a political system are beneficial, see.

The broader regression explains 35.43% of the variation in the data and although there is little meaning in this statistic alone, it shall be used to make comparisons between the volatility regressions explored here.

In the premise of the model, it has been shown that the institutional facets that have a significant effect on GDP growth volatility are those associated with good economic institutions, in particular through the association between settler mortality rates and property rights, and good political institutions, in particular through the association between political constraints and good governance.

In Table 2, the same regressors are used as in Table 1 with volatility of consumption as the dependent variable. In this case, it can be seen that in both the broader regression and in the regressions using each type of institutional instrument independently, that it is only the coefficient associated with settler mortality that is significant in either case.

In regression i, the settler mortality coefficient is positive, as also seen in the GDP growth volatility regressions, and highly significant. This relationship is persistent in the broader regression, the coefficient is still positive at the 1% level and is positive, albeit slightly lower.

The only other coefficients which display any significance are those associated with the control variables. In regression v, where the controls are used independently of any institutional instruments, absolute latitude and the dummy variable for an African country have associated coefficients which are significant at the 1% level. In both respects the coefficients of expected sign; the latitude coefficient is negative and the African coefficient is positive. In the broader regression, these coefficients cease to be significant and the negative coefficient of the Water-to-Land ratio is significant at the 10% level. This means that in the model, countries that have a greater proportion of their surface area comprised off water, ceteris paribus, experience less consumption growth volatility. Reasons for this could be related to

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Table 1.2: Dependent Variable: Consumption Volatility

	(1)	(2)	(3)	(4)	(5)
Settler Mort	1.756***				1.521***
	(0.327)				(0.501)
French LO		4.033***			-2.420
		(1.463)			(1.481)
British LO		3.686**			
		(1.535)			
Muslims			0.0277		0.0340
			(0.0193)		(0.0239)
Catholics			0.00830		0.0402
			(0.0170)		(0.0246)
Protestants			-0.0126		0.00337
			(0.0254)		(0.0482)
POLCON				-1.081	1.090
				(1.205)	(1.529)
Latitude					-1.839
					(4.112)
Country Size					-0.267
					(0.250)
Water/Land					-24.37*
					(13.38)
Landlocked					-1.106
					(1.415)
Africa					1.294
					(1.413)
Constant	-1.257	3.060**	5.828***	6.738***	1.933
	(1.600)	(1.330)	(1.271)	(0.887)	(3.396)
Observations	62	96	96	89	58
R^2	0.325	0.077	0.046	0.009	0.429

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

DOI: 10.2870/22962

access to trade through waterways, although this is only a tentative suggestion.

As all other coefficient associated with institutional instruments are insignificant in all regressions in this table, in can be said that the model suggests that it is purely the economic facets of the institution bundle that are significant in determining consumption growth volatility. Indeed, they seem to have a strong explanatory effect as the coefficient associated with settler mortality is highly significant in a regression equation that explains 42.88% of the variation in cross-country consumption growth volatility, a figure much higher than in the previous set of regressions.

This seemingly strong relationship economic facets and consumption growth volatility may be due to the effectiveness of property rights. Countries with previously higher settler mortality rates are much more likely to have poorly developed property rights. It may very well be the case that households in these economies do not save as, due to the threat of expropriation of assets, a rational decision maker may choose to consume a much greater proportion of income. This results in a lack of consumption smoothing, a breakdown of the permanent income hypothesis and volatility in consumption growth. Other institutional factors may have little bearing in this hypothetical, yet highly plausible, scenario.

In Table 3, regressions i to iv show that when using institutional instruments independently in the volatility of terms of trade regressions, it is only the political instrument that is insignificant and remains so in the broader regression, iv. In regressions i and iii, the coefficients of settler mortality and percentage of Muslims present in the population are positive, and thus consistent with previous results suggesting positive relationships with volatility, and significant at levels of 10% and 5% respectively.

However, both of these coefficients are insignificant in the broader regression, vi. Interestingly, when included as the sole dependent variable the coefficient for the French legal origin dummy is positive and significant at the 5% level, yet in the broader regression equation is negative and significant at the 10% level.

Although seemingly strange, this may be due to the inclusion of more developed, non-former colonies in observations of regression ii, which are then subsequently dropped when running the broader regression in the most part due to a lack of a corresponding settler mortality statistic. For a former colony however, the model suggest that an economy having a French Legal origin relative to any other, reduces the volatility of the terms of trade.

In regression v, it can be seen that absolute latitude again has a significant and negative sign, but this does not remain in the broader regression. Here it is also suggested that larger countries experience more terms of trade volatility, an effect that is present in the broader regression. Furthermore, the coefficient of the Water-to-Land ratio variable is negative and

DOI: 10.2870/22962

Table 1.3: Dependent Variable: Terms of Trade Volatility

	(1)	(2)	(3)	(4)	(5)
Settler Mort	3.305*				0.994
	(1.891)				(2.871)
French LO		12.85*			-18.88*
		(7.192)			(9.796)
British LO		5.373			
		(7.463)			
Muslims			0.194**		0.199
			(0.0797)		(0.140)
Catholics			0.156**		0.381**
			(0.0708)		(0.162)
Protestants			0.0419		0.0264
			(0.112)		(0.253)
POLCON				4.435	-1.950
				(6.098)	(8.034)
Latitude					-27.01
					(26.78)
Country Size					2.388*
					(1.328)
Water/Land					-150.6*
					(81.02)
Landlocked					3.420
					(7.550)
Africa					10.49
					(8.749)
Constant	8.537	12.15*	11.09**	18.70***	-13.63
	(9.257)	(6.695)	(5.260)	(4.395)	(18.98)
Observations	62	93	93	86	58
R^2	0.048	0.054	0.087	0.006	0.258

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

significant at the 10% level. These two results may be associated with access to trade; larger countries are more likely to have populations and markets situated further from international borders and countries with greater access to waterways are more likely to be linked to trade routes along those channels. It is reasonable to expect countries with more frequent trade occurrences to experience lower terms of trade volatility.

The coefficient of the variable of percentage of Catholics present in the population is positive and significant at the 5% level in both the narrow and broader regressions. As previously stated, contemporary research suggests that religion has an effect on certain aspects of the legal system. The regression equation, vi, can readily be interpreted as suggesting that the institutional factors that are significant in determining terms of trade volatility are aspects of the legal system and that also access to trade plays a significant role[12].

In table 4, all coefficients associated with institutional instruments are insignificant, with the exception of the coefficient of the variable of percentage of Protestants present in the population. This is negative and significant at the 1% level in both the narrow and broad regression equation. This suggests that having a higher percentage of Protestants in the population leads to a significant decline in the volatility of the log of net foreign direct investment.

Again, it may be tentatively suggested that the negative correlation between net FDI volatility and the variable for the percentage of Protestants has its roots in trust between the nations involved. Much of the world's FDI investment will originate from the largest economies, such as Germany, the US, UK and France. Given that these countries are mainly comprised of Protestants it may be that an implicit trust exists between these investor nations and the recipient countries due to common religious preferences[13].

[12]The relationship between access to trade and the volatility of terms of trade may be an interesting area of future research. It particular, what are the factors that determine trade frequency between countries and how does this frequency impact on the volatility of terms of trade.

[13]For more on trust and economic outcomes, see Guiso et al (2006) amongst others.

DOI: 10.2870/22962

Table 1.4: Dependent Variable: FDI Volatility

	(1)	(2)	(3)	(4)	(5)
Settler Mort	-0.0718				-0.109
	(0.0607)				(0.0729)
French LO		-0.0232			-0.181
		(0.143)			(0.193)
British LO		-0.167			
		(0.154)			
Muslims			-0.00108		-0.00516
			(0.00204)		(0.00324)
Catholics			-0.00150		-0.00399
			(0.00193)		(0.00317)
Protestants			-0.0104***		-0.0156***
			(0.00383)		(0.00579)
POLCON				-0.0788	-0.147
				(0.152)	(0.194)
Latitude					0.230
					(0.765)
Country Size					0.102***
					(0.0372)
Water/Land					0.922
					(1.426)
Landlocked					0.0783
					(0.184)
Africa					0.246
					(0.201)
Constant	1.898***	1.559***	1.683***	1.567***	1.253**
	(0.303)	(0.117)	(0.131)	(0.110)	(0.594)
Observations	71	135	133	113	66
R^2	0.020	0.012	0.060	0.002	0.331

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

DOI: 10.2870/22962

1.5 Conclusions

This paper has demonstrated the importance of trying to isolate and to recognize the varying effects of differing aspects of the institutional bundle. Using exogenous, objective instruments to represent economic, legal, political and cultural facets of 'institutions', results have shown that each of these instruments were significant in explaining a certain type of economic volatility. In summary, it seems that economic and political aspects have significant impacts on GDP growth volatility, economic and aspects have significant impacts on consumption growth volatility, legal and cultural aspects have significant impacts on terms on trade volatility and that cultural aspects have a significant impact on net FDI volatility. Although speculative suggestions have been proposed to explain these patterns, perhaps the most important thing which maybe be taken from these results is the following. It is no longer acceptable to aggregate the effects of differing institutional facets into one bundle that in turn is represented, or instrumented for, by a subjective measure of institutional quality. In terms of policy, declustering the institutional bundle and targeting specific areas may be much more effective than having a general form of 'institutional reform' policy.

Furthermore, if it is accepted, as above, that volatility is detrimental to long term economic growth (or indeed has any significant effect whatsoever), then a specific type of economic volatility may be dampened by policy targeted at the appropriate institutional facet. Thus, more clinical policy in the area of institutions with have positive affects on long term economic growth.

Mott, Graham (2010), Essays in Economic Development
European University Institute DOI: 10.2870/22962

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DOI: 10.2870/22962

1.6 Appendix A: Constructing POLCON

1.6.1 Methodology

If a spatial model, which allows for cross-country comparisons between large numbers of countries, is to be constructed there is a need to simplify the structure of political systems. However, those aspects of the political composition that are fundamental to the restriction of political change must be largely retained. The focus of the constructed measure will be on two such aspects: the number of veto points over policy outcomes and the distribution of preferences of the political actors that function therein.

It is assumed that political actors function within five key areas: the Executive (E), the Lower House of the Legislature (L1), the Upper House of the Legislature (L2), sub-Federal units (F) and the Judiciary (J). Each actors holds a preference, X_I, where $I \in [E, L1, L2, F, J]$, i.e. I represents one of the five given political institutions. There exists a status quo policy, X_0, and actors' preferences are identically and independently drawn from a one-dimensional and uniformly distributed policy space [0,1]. It is assumed that a political actor has a utility function given by:

$$U = -|X - X_I| \qquad U\tilde{}\,[-1, 0]$$

where X represents the policy outcome.

Furthermore, each actor has veto power over final policy decisions.

The measure of interest from this model is the extent to which a political actor is constrained in their choice of future policies. This variable is calculated as one minus the expected range of policies for which a change in the status quo policy can be agreed by all actors with veto power. If there exists an unchecked executive, they may always achieve policy outcome X_E, regardless of status quo policy, and is guaranteed level of utility 0. Thus, political constraints, calculated as one minus political discretion, are zero. Obviously, as the number of political actors with independent veto power increases so to does the level of political constraint.

Drawing on the assumptions regarding draws from the distribution, the preferences of political actors will exhibit the following expected difference, $1/(n + 2)$, where n is the number of political actors.

If it is assumed that there are only two actors in the political system, i.e. an Executive and a unicameral legislature, the expected preference difference is equal to 0.25. There exists six possible preference orderings of this game [see figure (a) below], each assumed to be equally likely. In two of these orderings, actors' preferences are spaced so that there is no policy outside of the status quo that both actors simultaneously prefer. Otherwise,

orderings give a closed form solution other than the status quo, the direction of which both actors agree on. However, without other 'rules of the game' that are country specific (such as movement order or relative costs) the exact value of the jointly preferred policy cannot be determined. Therefore, the measure of policy discretion used is the range of policy outcomes that are jointly preferred to the status quo. The expected level of political constraints for the game $\{X_E, X_{L1}\}$across the six possible orderings is 2/3.

This measure is based solely on the number of institutionalised (de jure) veto points and the assumption of uniformity of preference distribution. In order to incorporate de facto veto power into the model, information on the preferences, or alignment, of the various political actors is incorporated. For example, if the legislature were completely aligned with the Executive, the game then achieves the outcome in the original example, the Executive always achieves $X_E$and political constraints equal zero.

The composition of political branches needs to be taken into consider in cases when branches are neither completely aligned nor completely independent. Suppose that a legislature is dominated by an Executive-controlling party, then political constraints are negatively correlated with the size of this majority. In contrast, if a party opposing that which controls the Executive holds a legislative majority, then political constraints are positively correlated with the size of this majority. Furthermore, if the legislature consists of a large number of parties, i.e. is heavily fractionalised, this may lead to fewer constraints due to the difficulty in forming or maintaining coalition opposition. Thus, political constraint measures should include information on both partisan alignment and difficulty of coalition formation.

The probability that two random draws from a political branch are from different parties is used to approximate for fractionalisation, the formula being:

$$1 - \sum_{i=1}^{n} \left[\frac{(n_i - 1)\frac{n_i}{N}}{N - 1} \right]$$

where n is the number of parties, n_i represents the number of seats held by the ith party and N is the total number of seats. The final value of political constraints in a system where the branch is aligned with the Executive is thus equal to basic constraint value derived under complete alignment of the Executive and other political branches, plus the product of the fractionalisation index and the difference between basic constraint values under complete alignment and complete independence. In the case of the Executive party being in the minority , the constraint measure is calculate using a modified product term, of [1- fractionalisation index] and the difference in extreme basic constraint values. In cases of mixed alignment, a weighed sum of the two products is used.

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Calculations were carried out for 157 countries over the period 1960 to 1994 and averages over five year periods were taken.

1.6.2 Data Sources

Construction of a measure of political constraints based on the methodology described herein requires three types of data. First, information regarding the number of institutional players in a given polity; second, data on partisan alignments (including coalitions) across institutions; and finally, data on the party composition of legislatures. All countries were assumed to have an executive. Data on the existence of other political actors (unicameral and bicameral legislatures and sub-federal units) with substantive veto power was taken from the Polity database [see Gurr (1996)] and Derbyshire and Derbyshire (1996).

The above data sources were then supplemented by various issues of The Political Handbook of the World and The Statesman's Yearbook to note the party distribution of the legislature(s): specifically, whether the executive enjoy a majority a majority in one (or both) legislature(s) and how many seats in each legislature were controlled by each party. Based on this information, the values of institutional hazards were modified to form a preliminary measures of political constraints (POLCON) using the methodology described in the previous section.

Mott, Graham (2010), Essays in Economic Development
European University Institute DOI: 10.2870/22962

CHAPTER 2

DIVERSIFICATION IN PRIMARY COMMODITY PRODUCTION

2.1 Introduction

For many years, key international bodies such as the International Monetary Fund and the World Bank encouraged Least Developed Countries[1] to adopt a policy of Import Substitution Industrialisation[2]. This policy stance involved supporting strategic substitute producing domestic industries through subsidisation, creating disincentives for foreign direct investment, maintaining an overvalued currency and erecting tariffs as barriers to imports. Both in conception and enactment, this policy has been found to be wanting when it comes to addressing the needs of many LDCs. Although some countries experienced a degree of success with ISI, it is noticeable that these countries (e.g. Mexico, Argentina and Brazil) initially possessed generally higher living standards and larger domestic markets than would be typically associated with an LDC. Specifically, it has been argued that Africa's ISI policy failed due to lack of complimentary factors, namely education and infrastructure. As such, comparative advantage in those countries remained in the primary commodity producing sectors (Deaton, 1999). Indeed, it is due to the lack of these complimentary factors that seem to rule out the type of export orientated industrialisation policy that has been so successful in the Far East.

The theoretical basis for the policy of ISI was the Prebisch-Singer hypothesis[3] which states that there is a long term decline in real primary commodity prices relative to manufactures. However, more contemporary literature (Cuddington 1992, Diakosavvas and Scandizzo 1992, Bleaney and Greenaway,1993 etc.) which has, by using modern econometric methods, disputed this theory, showing that the presence of a trend is highly dependent on the data series used and that the data maybe be better explained by a single structural break. Accordingly, this paper proposes that the key issue of concern to LDCs, which are heavily reliant on the export of primary commodities, should not be any long term, relative decline as outlined by Prebisch and Singer but the highly volatile nature of commodity prices. The

[1] Henceforth, LDCs.
[2] Henceforth, ISI.
[3] Independently, Prebisch (1950) and Singer (1950).

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European University Institute
DOI: 10.2870/22962

implications of this type of volatility are widespread (Bidarkota and Crucini 2000, Blattman et al 2007, Van der Ploeg and Poelhekke, 2007 etc) and arguably have been one of the most fundamental causes in prohibiting development in poor countries.

This paper proposes a policy of diversification across primary commoditity production as a means, along the lines of modern portfolio theory, of dampening the effects of highly volatile commodity prices in LDCs. It is argued here that diversification would lead to an export bundle of primary commodities that provide a more stable income base for developing economies, which is especially important when considering the inability of governments to forecast commodity prices or suitably adjust fiscal policies to short-term commodity windfalls (Tornell and Lane, 1999). Furthermore, there is a vicious cycle associated with primary commodity price volatility and development, as the various methods through which economies could try to tackle this type of volatility are often lacking in LDCs due to a lack of financial development. As the expertise or infrastructure to create entities such as sovereign wealth funds is unavailable, this paper suggests that diversification across primary commodity production can act as a substitute for financial development in controlling volatility for those countries with the most poorly established economies.

Notably, diversification is not used in this paper as a byword for industrialisation. Nations that have a smaller proportion of primary industry, in comparison to secondary or tertiary sectors, tend to attain a better standard of economic development than others. Sala-i-Martin (1997) finds the fraction of primary exports in GDP to be negatively correlated with growth and this is an area which has been extensively researched. This is duly noted and is taken as given. The primary hypothesis of this paper is that when the size of the primary sector is control for, developing countries that exhibit diversification across the primary commodity sector will enjoy better economic conditions, specifically decreasing terms of trade volatility which can in turn promote GDP growth.

Finally, insofar as this paper also constitutes a policy recommendation, it has been highlighted above that long-term factors such as education and infrastructure need to be addressed in order for industrialisation to be successful. As these factors are often conspicuous by their absence in LDCs, this would imply that the size of the primary sector is relatively persisistent, due to the time it takes for factor accumulation. Diversification is therefore a means of addressing a primary sector of a given size but, importantly, is not offered as a long term alternative to industrialisation.

The rest of this paper is organised as follows: section 2 surveys the literature, section 3 outlines the nature of the proposed solution, section 4 presents empirical analysis and section 5 concludes.

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2.2 Literature Overview

2.2.1 On the Behaviour of Commodity Prices

A typical LDC will be heavily reliant on the export of primary commodities as a source of income and a large part of the capital and labour resources of that country will be devoted to the production of those commodities. The integral issue of the problem is the manner in which governments of LDCs react to volatile commodity price movements and in what part public policy is geared up to accommodating primary product price fluctuations. Understanding the behaviour and effects of commodity prices will be critical to the success of the country and there has been much academic focus on this issue.

Firstly, commodity prices seem to display some similar characteristics; Deaton and Laroque (1992) finds significant second order auto-correlation, low persistence, positive skewness[4] and largely positive kurtosis[5]. Secondly, Deaton and Laroque (1992) strongly rejects the random walk hypothesis of commodity prices[6] and this rejection calls into question the public policy behaviour demonstrated by countries particularly reliant on income generated by primary commodities. Tornell and Lane (1999) highlights notable cases, such as Costa Rica and the Ivory Coast during the coffee prices shocks of 1975, of a negative correlation between a country's terms of trade and its current account. This implies that countries have a tendency to overspend received windfalls, even in cases where windfalls are induced by temporary shocks[7]. Reasons for this overspending are likely to include poor quality or undisciplined fiscal policy, corruption and political rent seeking. This problem is perhaps accentuated by policymakers making poor predictions[8] on the movements of commodity prices; a task not aided by high volatility.

The inability to forecast commodity prices is not a problem that is confined to governments and policymakers in developing countries either. Figures 1-2[9] show that often, those global institutions that offer 'expertise' can themselves be wildly wrong about future price movements of the main sources of income for developing economies.

In short, commodity prices exhibit infrequent, positive spikes that have low persistence, such that these shocks cannot be considered permanent. However, governments in developing

[4]There are relatively few downward spikes in comparison to upward spikes.

[5]The variance is caused largely by occasional, but more extreme, deviations from the mean.

[6]A true random walk would achieve a level of persistence equal to unity. Deaton and Laroque (1992) find a value closer to 0.3.

[7]This also holds when the nature of the shock is common knowledge. For instance, the spike in coffee prices during 1975 was caused by a severe frost which devastated Brazil's coffee crop in July of that year. The world price doubled overnight and in the following weeks reached up to eight times the pre-frost level.

[8]See Collier et al. (1999).

[9]Source: Deaton and Miller (1995)

 DOI: 10.2870/22962

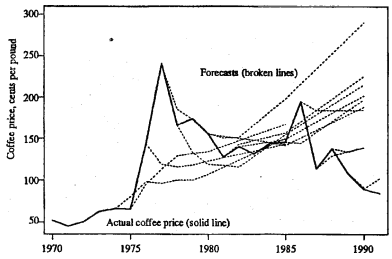

Figure 2.1: World Bank Coffee Price Forecasts

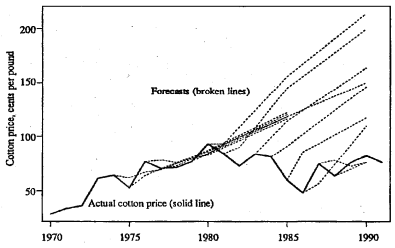

Figure 2.2: World Bank Cotton Price Forecasts

countries often treat these shocks as highly persistent and adjusting fiscal policy accordingly, even overspending temporary windfalls. As a result, it has been suggested that, essentially temporary, higher commodity prices may in fact be detrimental to countries that rely on primary products for a substantial part of their income, not just in terms of volatility but also in terms of the policy approach to any upward change (Asea and Lahiri, 1999).

Whilst it is clear to see how volatility of commodity prices can have adverse effects for LDCs, the long term trend in prices is of key importance in the argument presented here. The Prebisch-Singer hypothesis states that there is a long-term decline in the real price of primary commodities relative to manufactures. Essentially, it is this hypothesis that has been the theoretic basis for the policy of ISI. At first, any policy recommendation that advocates focusing on the production of primary commodities would seem, in light of this hypothesis, to be contracting LDCs to generations of worsening impoverishment. However, this paper suggests that the issue of long-term relative price decline of primary commodities should be of secondary, or even little, concern to LDC in comparison to primary commodity price volatility. While this hypothesis gained much support from its inception, more advanced econometric analysis in later years cast substantial doubt over its observations. Cuddington (1992) refutes the existence of widespread effects as prescribed by the Plebisch-Singer hypothesis, suggesting that secular deterioration in primary commodity prices should not

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be considered a universal phenomenon or as a stylised fact. Diakosavvas and Scandizzo (1992) finds evidence that the hypothesis holds for only a handful of primary commodities. Furthermore, Bleaney and Greenaway (1993) demonstrates that if data prior to the mid 1920s is excluded from the analysis of real commodity prices relative to manufactures, then a structural break in the early 1980s fits the data better than a smooth trend. They conclude that price instability is a more serious issue than long-term decline in the terms of trade, particularly from the perspective of those countries which are heavily dependent on a narrow range of primary commodity exports.

2.2.2 On the Importance and Effects of Volatility on Growth

It should be stressed that commodity price volatility has real effects on the growth rate of economies, not just through the medium of policy or corruption. Blattman et al (2007) demonstrates that countries with a greater volatility of primary product prices grow more slowly relative to other primary product exporters. Bidarkota and Crucini (2000) show that when holding fixed the total share of raw materials in national exports, the most important factor in terms of trade variation is the price volatility of the particular commodities in which a country specializes. Indeed, Van der Ploeg and Poelhekke (2007) suggests that the natural resource curse is driven by an indirect negative effect of natural resource abundance; an effect transmitted by volatility and one which is strong enough to outweigh any direct positive effect associated with the presence of abundant natural resources. The same paper shows that countries with less well developed financial systems are much more volatile; countries in the bottom quartile of financial development have a standard deviation of annual per capita GDP growth two percent higher than those in the top quartile. Elbers et al (2007) carries out a DSGE case study of Zimbabwe, finding that financial market incompleteness and observed commodity price volatility depresses capital accumulation and output by around forty percent. Koren and Tenreyro (2007) cites the fact that poor countries specialise in fewer industries as one of the four reasons why poor countries experience higher volatility in growth rates.

Given the problems highlighted above, it would seem that volatility reduction should be a key goal of developing economies. The development of more complex domestic financial markets would provide mechanisms that could reduce the effects of volatility by allowing for those economies to self-insure. This could be done through participation in long term contracts, hedging, investment in sovereign funds etc. Specifically, in the case of terms of trade volatility, financial development may act as a constraint of government policy insofar

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as when a primary commodity price spikes, a government response is limited by developed financial markets either because powers have been devolved to those markets or the presence of those markets results in 'more responsible' actions. In the latter case, it could be argued that the outcome is akin to a type of debt overhang or similar 'watchdog' effect. If the ability to respond fiscally is constrained then the tendency to overspend windfalls, as noted by Tornell and Lane (1999), will also be appropriately limited. As terms of trade is measured as the value of exports relative to the value of imports, if the change in the value of imports overshoots the change in the value of exports due to a temporary price shock, as in Tornell and Lane (1999), this will lead to increased terms of trade volatility. Dampening overshooting will thus lead to lower terms of trade volatility.

However, LDCs will almost certainly lack the complex financial markets, or the ability to quickly generate them, which would enable these economies to take the appropriate measures. Thus, as a solution this paper will turn to diversification across the production of primary commodities as a means of dampening volatility.

2.3 On the Nature of the Proposed Solution

From Modern Portfolio Theory, it is known that increasing the number of stocks held in a given portfolio can reduce the volatility of the portfolio. An investor can reduce portfolio risk simply by holding instruments which are not perfectly correlated. In other words, investors can reduce their exposure to individual asset risk by holding a diversified portfolio of assets. Efficiently applied diversification will allow for the same expected portfolio return with reduced risk exposure. The same logic is appealed to in order to suggest a reduction in the price volatility of an export bundle.

By diversifying across the production of primary commodities, national income becomes less dependent on the price movements of a single commodity. Bleaney and Greenaway (1993) shows that there is very little co-movement in commodity prices and where these co-movements do exist it is often, bizarrely, across very different types of commodities, e.g. wheat and lead. Although commodity prices exhibit similar characteristics, there seems to be very imperfect correlation across commodity prices and under the previously stated assumptions, it would appear that diversification across production could be beneficial to LDCs.

This policy would seem, however, to be completely at odds to the conclusions of the most fundamental of trade of models (Ricardian and Heckscher-Ohlin) and limit the opportunity for poor countries to achieve the economies of scale associated with specialisation.

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With regards to the former, these models advocate production, or specialisation, along the lines of comparative advantage. As this paper will endorse diversification across the primary commodity sector, LDCs would still be participating in labour intensive industries and thus would be fulfilling the conclusions of these models. It would remain though that diversification would inhibit the achievement of economies of scale and so a policy of diversification would lead to costs in terms of forgone gains from specialisation. Yet the Lewis Critique[10] would suggest that developing countries do not realise these gains anyhow. The critique states that real wages cannot grow, even in the presence of productivity increases, if there exists a (theoretically) unlimited supply of labour at the subsistence wage. The benefits of technological progress therefore accrue to consumers in industrialised countries rather than workers. This would seem to be a plausible fit for many LDCs and the effect is reinforced by the fact that in many cases capital is foreign owned.

A key question that must be addressed is whether or not diversification, in terms of the actual physical ability of an economy to produce a wider range of primary products, is a plausible policy recommendation. The two most immediate problems would seem to be geography and availability of primary mineral resources. Obviously, countries cannot diversify by producing mineralogical primary commodities if no ore is present within the country's territory and the range of 'renewable' primary commodities that can be feasibly produced within a country will be affected by geography. Firstly, the majority of primary commodities taken into account in the WTA database[11] are not primary mineral commodities and so there is much scope for diversification across renewable primary commodities. The Government of Angola has recently announced a 5 year, $6 billion dollar agricultural program aimed at reducing the nation's reliance on oil and diamonds. Secondly, geography can, for many reasons, greatly affect transportation costs associated with exportation; size of country, access to waterways, landlocking, mountainous terrain, distance from nearest port etc. However, even in the more extreme cases this has not prevented countries from diversifying, albeit when previously *forced* to, e.g. Colombia's move away from tobacco production when faced with low cost competition from Indonesia and Brazil's shift from natural rubber in response to Malaysian competition and the invention of sythentics.

Furthermore, as stated above diversification as described here may be effective in controlling volatility in economies that lack the channels that financial development would otherwise allow. Diversification will reduce the importance of a single commodity in the country's export bundle and as commodities do not typically exhibit significant co-movements, price

[10] See Lewis (1954)

[11] For the list of commodities used in this paper, see Appendix A

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spikes of a single commodity will not have as great effect on the price of the total bundle. This implies that revenue will be flatter, more predictable and will not give rise to as many occasions when governments overspend. Therefore, terms of trade volatility may be reduced.

On the face of it, diversification across the primary commodity sector would seem to be a feasible solution to some of the key issues facing LDCs, particularly exposure to primary commodity price volatility. Empirical analysis is presented to support this assertion.

2.4 Empirics

2.4.1 Diversification as a dampener to Volatility

This paper uses cross country regressions to investigate the relationship between terms of trade volatility and diversification across primary product production. All data is from the World Trade Analyzer unless otherwise stated. Initially, the regression specification is as follows:

$$\sigma_i = \alpha + \beta_1 NPC_{i,s,t} + \beta_2 R_{i,t} + \mu D_{i,t} + \varphi Z_i + \varepsilon_{i,t}$$

The dependent variable, σ_i, is the volatility of terms of trade for country i and is measured as the standard deviation of a terms of trade index[12] over the period 1985 to 2007. $NPC_{i,s,t}$is the number of primary commodities that the country i produces in year t which have an export share greater than or equal to the specified threshold, s. Different threshhold levels were used to check to robustness of the model; 1%, 2.5% and 5% of total exports. These levels were chosen so that there would exist sufficient variation between countries in the data without including commodities with negligable export significance. $R_{i,t}$ measures the ratio of values of primary sector exports to all exports[13]. $D_{i,t}$ encapsulates two economic control variables. Firstly, openness as measured by exports as a fraction of GDP and secondly, the log of GDP[14]. Z_t captures a number of geographic and institutional controls; log of land area, water-to-land ratio, average elevation, a dummy for being landlocked, percentage of population living in a Koeppen-Geiger temperate zone[15], a dummy variable for African countries, a dummy variable indicating French legal origin[16] and the percentage of the population recognised as Catholics in 1980[17]. Most of these controls are standard in the

[12]Source: World Development Indicators (WDI)

[13]Results tables display this variable as P/Ex Ratio

[14]Source: WDI. This measure of GDP was used so as to capture the 'size of domestic market' effect which enabled some economies to be successful under ISI policies.

[15]Source: CID, General Measures of Geography

[16]Source: La Porta et al (1999)

[17]Source: La Porta et al (1999)

DOI: 10.2870/22962

literature and studies often find geography has significant effects on volatility (Malik and Temple, 2005). Institutional controls are limited to legal origin and religion as in previous work[18] these have been shown to be more frequently significant, than political or economic institutional facets, in explaining differences in terms of trade volatility.

The above specification is run using the three different threshhold levels and four different years; 1987, 1990, 1995 and 2000. Collating this data as a single dynamic panel was not possible due to the unbalanced nature of the data available and earlier years are used, with respect to the range of volatility, to limit potential endogeneity. Results of these regressions are shown in Tables 1-4.

From Table (1), it can be seen that at each threshhold value and using the prescribed controls, the coefficients of interest are strongly significant and appear with the expected sign. Results show, in accordance with the literature cited above, that an economy with a larger share of primary commodity in exports will experience significantly higher volatility in its terms of trade. Again, it is this result that has been the driving force behind industrialisation policies aimed at LDCs in the past. Also, openness can play a significant role in reducing terms of trade volatility. Most importantly, these results support the hypothesis of this paper; that an increase in the number of primary commodities produced can lower terms of trade volatility, as the coefficient at each threshhold level is strongly significant and a negative. Indeed, as the threshhold, s, is lowered, it can be seen that the explanatory power of the diversification variable increases, from regressions (4) through (6), as the p-value decreases and the explanatory power of the specification as a whole increases markedly. To argue that this is a result of the inclusion of more data would be wrong. Lowering the threshhold allows for more variation across countries in the number of primary products in exports, which may be important if insufficient variation exists in the data if the threshhold is set too high. However, this risks including commodities with levels of production that would seem insignificant. Clearly, the latter is not occuring here so it seems therefore, that diversification on a relatively small-scale may be conducive to lowering terms of trade volatility. Furthermore, crude analysis of these results suggests that producing and exporting an additional primary commodity, so that its export share surpasses the 1% threshold, can reduce terms of trade volatility as, ceteris paribus, the dampening effect of diversification will outweigh the stimulating effect of increasing the ratio of primary commodities in exports. The features of these results are quite robust to changes in year as can be seen from comparisions of Tables 1-4.

[18] See Mott, "*A Further Unbundling of Institutions" 2008*

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2.4.2 Robustness

2.4.2.1 Endogeneity

In order to test for the presence of serious endogeneity in the specification used above, volatility of terms of trade data is used as an explanatory variable, the number of primary commodities is used as the dependent variable and standard controls are included. The specification is as follows:

$$NPC_{i,s,t} = \alpha + \beta_1 \sigma_{e,i} + \mu D_{i,t} + \varphi Z_i + \varepsilon_{i,t}$$

where all variables have the same definition as previously stated and $\sigma_{e,i}$ is the volatility of a country's terms of trade, measured as the standard deviation of a terms of trade index over the period 1980 to 1990. The regression is run six times using the previous primary commodity export share threshholds as before and data for the years 1995 and 2000. These time periods were chosen as it is assumed that any affect from volatility on production would not be instantaneous due to relatively inelastic supply. From the results seen in Table 5, there is strong evidence to reject serious endogeneity in the original specification as in five of the six regressions, terms of trade volatility does not prove to be significant[19].

2.4.2.2 Diversification Measure

The measure of diversification used in the specifications above is intentionally simple, so as to highlight the strength of the result. In order to qualify the preceding results, that terms of trade volatility may be dampened by diversification across primary commodity production, a concentration index is used. A Herfindahl Index is given by:

$$H_i = \sum_{i=1}^{N} c_i^2$$

where, for the purposes of this paper, N is the number of commodities and c is the export share. The lower the value of the Herfindahl Index, the more diversified the primary commodity exports of a given economy. A normalised version of this index, $H_{i,t}$, is used as the diversification measure, so the specification is as follows:

$$\sigma_i = \alpha + \beta_1 H_{i,t} + \beta_2 R_{i,t} + \mu D_{i,t} + \varphi Z_i + \varepsilon_{i,t}$$

This specifiction is run once for each of the four years of the initial specification.

[19] Interestingly, religion is strongly significant in all six of the regressions in Table 5.

DOI: 10.2870/22962

Tables 6-9 show that, even when using a more complex measure of diverification, the results support the hypothesis that diversification (in this case defined as lower concentrations of any given commodity in the primary commodities share of exports) is associated with lower terms of trade volatility. In each of the four regressions, strongly significant and positive Herfindhal Index coefficients show that, in the data, terms of trade volatility increases with the concentration of commodities which constitute primary exports.

2.4.3 Diversification as a Financial Development Substitute

The second part of the hypothesis of this paper is that diversification across primary commodity production can act as not only as a dampener of terms of trade volatility but can act also as a substitute for financial development in the least economically developed nations. In order to test this hypothesis, the following specification is used:

$$\sigma_i = \alpha + \beta_1 NPC_{i,s,t} + \beta_2 FN_{i,s,t} + \beta_3 F_{i,t} + \beta_4 R_{i,t} + \beta_5 X_{i,t} + \varphi Z_i + \varepsilon_{i,t}$$

where $NPC_{i,s,t}$, $R_{i,t}$ and Z_i have the same definitions as before. $F_{i,t}$ is the country's level of financial development[20], measured by the level of domestic credit to the private sector as a percentage of GDP[21]. $FN_{i,s,t}$ is an interactive variable[22] between financial development and the number of primary commodities with an export share greater than s. $X_{i,t}$ represents openness as measured by exports as a fraction of GDP. This specification does not include GDP as an explanatory due to the possibility of high collinearity with the variables of interest.

Tables 10-13 show the results from these regressions, using the same four time periods and two primary export share threshhold levels; 1% and 2.5%. Using the two lowest threshhold levels ensures adequate variation in the data as discussed above. For 1987, the model performs poorly in terms of the newly introduced financial development variables; neither achieve significance at either of the primary commodity export share threshholds. It is difficult to make comparisons from samples using 1987 data and other years due to the unbalanced nature of the data. However, the financial variables of interest perform well in the other regressions; in five of the six regressions both variables, financial development and the interactive variable between financial develoment and diversification are significant and

[20]Results tables display this variable as Fin Dev

[21]Source: WDI

[22]Results tables display the interactive variable as FDNPC1 at the 1% threshhold and FDNPC2 at the 2.5% threshhold.

have the expected signs. The results suggest that increased levels of financial development are associated with lower levels of terms of trade volatility, the associated coefficient being negative. It should be noted that, ceteris paribus, this effect does not crowd-out the significance of diversification as in all six regressions this variable remains strongly significant and negative. However, the interactive variable between diversification is significant in each of the regressions in which the variable for financial development is significant. The positive coefficient of the interactive variable implies that there is a diminising return to diversification in terms of financial development; the higher the initial level of financial development, the lower the effect on terms of trade volatility of increasing diversification. Furthermore, there should exist a level of financial development for which increasing diversification of primary commodities has no effect on terms of trade volatility, which would be given by this specification as:

$$\frac{\partial \sigma_i}{\partial N_{i,s,t}} = \beta_1 + \beta_2 F_{i,t} = 0$$

This critical level is thus given by:

$$F^*_{i,t} = \frac{\beta_1}{\beta_2}$$

These critical levels are calculated for each regression in which the financial development achieve significance. When the export share threshhold, s, is set at 2.5%, critical levels of financial development are 83.70, 71.00 and 83.32 for the years 2000, 1995 and 1990 respectively, with an average of 82.82. For $s = 0.01$, critical levels are 95.34 and 70.29 for years 2000 and 1995, averaging 79.34. In the data for the year 2000, countries such as Jordon (77.81), Grenada (79.27) and St. Lucia (80.07) all have similar levels of financial development to the averages of the critical levels calculated here[23]. The majority of countries in the data have financial development levels significantly below this, with only the Asian Tigers and First World economics achieving consistently higher levels. These figures seem to support the secondary hypothesis of this paper insofar as the average critical levels are reassuring high. Under this specification, diversification continues to be a viable policy for dampening terms of trade volatility and acts as a substitute for financial development until an economy has achieved an above average level of financial development. Thus, the poorest, most under-developed economies seem most able to benefit from increased diversification across primary commodity production.

[23]Incidently, these countries also share very similar HDI values: Jordan (0.773), St Lucia (0.795) and Genada (0.777).

Notice that this simple specification suggests that for any level of financial development beyond the critical level of financial development, $F^*_{i,t}$, then diversification across primary commodities can lead to an increase in terms of trade volatility. In essence, there exists a Laffer curve, in terms of financial development, to explain the relationship between diversification and terms of trade volatility. Whilst this is an inevitable consequence of the regression specification, it may be valid to suggest that beyond a critical level that diversification has *no effect* in practice and that this critical level of financial development signals the point when the Lewis Critique begins to break down. As economies become more developed, labour markets tighten, there exists greater opportunities for capital investment by domestic agents and financial development, by the same measure used in this paper, increases. Consequently, real wages will rise, the propensity for gains from specialisation to accrue to foreign agents diminishes and this will impact on domestic consumption, the demand for imports and ultimately, the terms of trade structure. Therefore, in this scenario, if specialisation leads to less volatility in terms of trade movements, a policy of diversification may increase volatility in terms of trade if financial development has exceeded a certain threshhold. This however, is only a tentative suggestion and is a question left for future research.

2.5 Conclusions

This paper has argued that the foremost concern of LDCs that are heavily reliant on the export of primary commodities should not be the long term decline in real commodity prices, as prescribed by the Prebisch-Singer hypothesis. Previous literature, using more advanced econometric techniques, has provided evidence that this long term decline is in fact a fallacy and that the data is better explained by the occurrence of, at most, two structural breaks in the data. Instead it is the volatility of primary commodity prices that should be of chief concern. Presented empirics have shown that a policy of diversification in the production of primary commodities can play an important role in directly dampening terms of trade volatility. The intuition is simple: that diversification reduces reliance on a single commodity and if commodity prices are not perfectly correlated, modern portfolio theory suggests the possibility of constructing an array of primary commodity exports with the same return and lower variance. There is strong evidence to support this assertion. Furthermore, analysis of the data also suggests that diversification acts as a substitute for financial development in countries with poorly established economies. In these economies, increased diversification lowers terms of trade volatility and continues to do so until the economy reaches critical level of financial development. Thereafter, increased diversification may actually increase terms of trade volatility. In the context of this paper, this critical level of financial development

 DOI: 10.2870/22962

is reassuringly high; indeed it is a level of financial development significantly higher than is averagely observed across all countries. Therefore, the results presented here suggest a policy of increased diversification in primary commodity production will significantly reduce terms of trade volatility in LDCs and may do so by acting as a substitute for financial development as, almost by definition, these economies will fall significantly below the financial development threshhold.

Mott, Graham (2010), Essays in Economic Development
European University Institute DOI: 10.2870/22962

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2.6 Appendix A: Commodities List

Wheat, rice, meat, dairy, fish, barley, maize, vegetables (fresh), vegetables (prepared), oranges, bananas, apples, grapes, figs, fruit (preserved), sugar, coffee, chocolate, tea, spices, animal feed, beverages (non-alcoholic), beverages (alcoholic), tobacco, peanuts, soya, cotton seeds, sunflower seeds, sesame seeds, rape seed, copra, linseed, caster oil seeds, rubber, wood, silk, cotton, jute, flax, true hemp, sisal, wool, guano, natural sodium nitrates, natural phosphates, potassium salts, stone, sulphur, clays, common salt, slag, iron ores, uraninite, copper ores, nickel ores, aluminium ores, lead ores, zinc ores, tin ores, manganese ores, coal, natural gas, animal oils, soya oils, cotton oil, peanut oil, sunflower oil, linseed oil, coconut oil, caster oil, olive oil, palm oils, fixed vegetable oil, essential oils, nitrogen fertilizer, phosphate fertilizer, pos fertilizer, silk yarn, wool yarn, cotton yarn, quicklime, pearls, iron and steel, copper, nickel, lead, zinc, tin, silver and platinum, uranium, aluminium, gold skins, diamonds, petroleum oils, live animals.

NB. Where extremely similar products were listed separately under WTA classification, these products were aggregated. This does not represent a totally comprehensive list as some subcategories within WTA database include 'not explicitly specified' or residual terms. When these terms were substantial, matches were attempted using various country guides. If one was not found, this term was counted as a single commodity.

2.7 Tables

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Table 2.1: Dependent Variable: Terms of Trade Volatility, t=1987

	(1)	(2)	(3)	(4)	(5)	(6)
NPC(s=0.05), t	-1.322			-2.780**		
	(0.898)			(1.053)		
NPC(s=0.025), t		-1.419**			-2.171***	
		(0.609)			(0.721)	
NPC(s=0.01), t			-1.175***			-1.689***
			(0.340)			(0.394)
P/Ex Ratio, t				76.38**	79.50***	71.13**
				(29.92)	(29.49)	(27.92)
Openness, t				-60.26**	-66.44**	-65.47**
				(28.96)	(28.64)	(27.00)
GDP, t				-1.012	-0.743	-0.928
				(1.281)	(1.232)	(1.161)
Country Size				1.667	1.688	2.138*
				(1.340)	(1.306)	(1.233)
Water/Land				-35.13	-39.72	-44.57
				(31.73)	(31.26)	(29.55)
Elevation				-1.935	-1.860	-1.822
				(1.862)	(1.817)	(1.695)
Landlocked				1.932	3.310	3.032
				(4.421)	(4.278)	(4.038)
Temp. Zone Land				-2.112	1.193	0.985
				(8.839)	(8.839)	(8.284)
Africa				5.555*	5.221	3.473
				(3.222)	(3.178)	(3.035)
French Legal Origin				0.701	-0.524	-0.522
				(3.374)	(3.393)	(3.165)
Catholics				0.0372	0.0504	0.0478
				(0.0505)	(0.0507)	(0.0455)
Constant	21.07***	23.51***	25.86***	36.02	31.91	35.34
	(2.708)	(2.850)	(2.690)	(23.75)	(22.75)	(21.34)
Observations	98	98	98	81	81	81
R^2	0.022	0.053	0.111	0.334	0.352	0.422

Standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

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Table 2.2: Dependent Variable: Terms of Trade Volatility, t=1990

	(1)	(2)	(3)	(4)	(5)	(6)
NPC(s=0.05), t	-1.312			-2.830***		
	(0.953)			(1.003)		
NPC(s=0.025), t		-1.493***			-1.919***	
		(0.554)			(0.646)	
NPC(s=0.01), t			-1.198***			-1.480***
			(0.317)			(0.383)
P/Ex Ratio, t				78.89***	64.30**	63.34**
				(24.82)	(24.99)	(23.99)
Openness, t				-53.96**	-48.26**	-54.23**
				(23.55)	(23.39)	(22.55)
GDP, t				-0.226	-0.540	-0.618
				(1.243)	(1.263)	(1.198)
Country Size				1.299	1.538	1.785
				(1.262)	(1.278)	(1.218)
Water/Land				-30.30	-30.10	-38.44
				(30.69)	(30.52)	(29.26)
Elevation				-1.217	-1.050	-1.203
				(1.701)	(1.681)	(1.619)
Landlocked				4.769	2.182	1.559
				(4.125)	(4.282)	(4.097)
Temp. Zone Land				-3.710	-3.729	-1.575
				(7.339)	(7.290)	(7.082)
Africa				5.238*	5.266*	4.184
				(3.067)	(3.049)	(2.917)
French Legal Origin				2.562	0.870	0.405
				(3.185)	(3.283)	(3.144)
Catholics				0.00759	0.0291	0.0464
				(0.0465)	(0.0488)	(0.0471)
Constant	20.87***	24.07***	25.94***	15.70	22.33	26.05
	(2.726)	(2.719)	(2.526)	(23.23)	(23.67)	(22.63)
Observations	98	98	98	83	83	83
R^2	0.019	0.070	0.129	0.361	0.368	0.414

Standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

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Table 2.3: Dependent Variable: Terms of Trade Volatility, t=1995

	(1)	(2)	(3)	(4)	(5)	(6)
NPC(s=0.05), t	0.0347			-2.698**		
	(0.933)			(1.073)		
NPC(s=0.025), t		-0.861			-1.795***	
		(0.569)			(0.621)	
NPC(s=0.01), t			-1.027***			-1.260***
			(0.351)			(0.404)
P/Ex Ratio, t				61.16***	53.74***	49.15***
				(17.49)	(17.12)	(17.07)
Openness, t				-33.18**	-30.68**	-29.99**
				(13.61)	(13.35)	(13.22)
GDP, t				0.0286	0.356	0.513
				(1.361)	(1.302)	(1.278)
Country Size				1.165	1.090	0.951
				(1.296)	(1.252)	(1.222)
Water/Land				-42.60	-38.19	-35.18
				(31.44)	(31.06)	(30.85)
Elevation				-1.799	-1.564	-1.246
				(1.737)	(1.689)	(1.659)
Landlocked				5.294	5.981	4.530
				(4.335)	(4.253)	(4.263)
Temp. Zone Land				-6.396	-4.595	-2.173
				(7.546)	(7.528)	(7.622)
Africa				5.639*	5.410*	5.112
				(3.209)	(3.164)	(3.137)
French Legal Origin				2.336	2.819	1.811
				(3.323)	(3.267)	(3.264)
Catholics				0.0127	0.0320	0.0375
				(0.0465)	(0.0478)	(0.0476)
Constant	17.24***	20.82***	24.25***	13.75	6.134	4.962
	(2.573)	(2.638)	(2.669)	(25.22)	(23.88)	(23.53)
Observations	98	98	98	83	83	83
R^2	0.000	0.023	0.082	0.334	0.351	0.362

Standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

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Table 2.4: Dependent Variable Terms: of Trade Volatility, t=2000

	(1)	(2)	(3)	(4)	(5)	(6)
NPC(s=0.05), t	0.254			-2.060**		
	(0.841)			(1.006)		
NPC(s=0.025), t		-0.662			-1.270**	
		(0.508)			(0.570)	
NPC(s=0.01), t			-0.909***			-0.989**
			(0.323)			(0.376)
P/Ex Ratio, t				52.65***	48.52***	45.85***
				(11.38)	(11.21)	(11.14)
Openness, t				-24.53**	-22.58**	-23.85**
				(9.495)	(9.223)	(9.159)
GDP, t				0.571	0.910	0.910
				(1.209)	(1.140)	(1.116)
Country Size				0.358	0.382	0.316
				(1.129)	(1.119)	(1.087)
Water/Land				-11.77	-12.17	-19.43
				(29.56)	(29.40)	(29.05)
Elevation				-1.851	-2.076	-1.665
				(1.589)	(1.592)	(1.555)
Landlocked				8.781**	8.351**	7.080*
				(3.942)	(3.920)	(3.908)
Temp. Zone Land				-6.809	-5.562	-3.394
				(6.987)	(7.017)	(7.070)
Africa				5.244*	5.605*	5.538*
				(2.939)	(2.934)	(2.893)
French Legal Origin				2.428	2.589	2.163
				(3.157)	(3.109)	(3.086)
Catholics				0.0156	0.0299	0.0330
				(0.0450)	(0.0472)	(0.0454)
Constant	16.78***	20.04***	23.49***	7.863	0.696	2.065
	(2.435)	(2.387)	(2.490)	(22.72)	(21.06)	(20.69)
Observations	99	99	99	85	85	85
R^2	0.001	0.017	0.075	0.422	0.428	0.442

Standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

DOI: 10.2870/22962

Table 2.5: Dependent Variable: No. of Primary Commodities

	t=1995, s=0.01	t=1995, s=0.025	t=1995, s=0.05	t=2000, s=0.01	t=2000, s=0.025	t=2000, s=0.05
Terms of Trade Volatility	-0.0190	-0.00479	0.00151	-0.0276*	-0.00930	-0.00415
	(0.0151)	(0.0101)	(0.00655)	(0.0158)	(0.0102)	(0.00645)
Country Size	0.523**	0.351**	0.178	0.273	0.262	0.0407
	(0.253)	(0.171)	(0.110)	(0.273)	(0.176)	(0.111)
Water/Land	5.628	2.319	-0.291	4.561	5.705	2.548
	(8.667)	(5.834)	(3.767)	(9.343)	(6.024)	(3.803)
Elevation	-0.333	-0.440	-0.430**	-0.371	-0.538*	-0.266
	(0.457)	(0.308)	(0.199)	(0.493)	(0.318)	(0.201)
Landlocked	-0.459	0.438	0.0850	0.663	1.099	1.028**
	(0.999)	(0.673)	(0.434)	(1.073)	(0.692)	(0.437)
Temp. Zone Land	4.685**	1.471	-0.156	4.612**	1.409	-0.145
	(2.023)	(1.362)	(0.879)	(2.180)	(1.405)	(0.887)
Africa	0.249	0.415	0.624*	1.289	1.085*	0.724**
	(0.802)	(0.540)	(0.349)	(0.857)	(0.552)	(0.349)
French Legal Origin	-0.696	-0.0171	-0.248	-1.004	-0.737	-0.522
	(0.867)	(0.584)	(0.377)	(0.935)	(0.603)	(0.381)
Catholics	0.0525***	0.0327***	0.0152***	0.0633***	0.0454***	0.0204***
	(0.0118)	(0.00794)	(0.00513)	(0.0127)	(0.00816)	(0.00515)
Constant	1.223	1.107	2.193*	4.022	2.446	2.648**
	(3.009)	(2.025)	(1.308)	(3.244)	(2.091)	(1.320)
Observations	87	87	87	88	88	88
R^2	0.296	0.236	0.157	0.302	0.336	0.288

Standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

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Table 2.6: Dependent Variable Terms: of Trade Volatility, t=1987

	(1)	(2)
Norm Herf	27.28***	34.26***
	(4.219)	(6.909)
P/Ex Ratio, t		-36.60
		(35.71)
Openness, t		24.53
		(31.13)
GDP, t		-2.297*
		(1.194)
Country Size		2.299*
		(1.189)
Water/Land		-30.54
		(28.57)
Elevation		-1.596
		(1.627)
Landlocked		-1.975
		(4.095)
Temp. Zone Land		3.862
		(8.076)
Africa		1.370
		(3.012)
French Legal Origin		0.106
		(3.032)
Catholics		0.0181
		(0.0421)
Constant	10.39***	43.16**
	(1.541)	(20.89)
Observations	98	81
R^2	0.303	0.461

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

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Table 2.7: Dependent Variable Terms: of Trade Volatility, t=1990

	(1)	(2)
Norm Herf	30.50***	39.50***
	(4.016)	(6.649)
P/Ex Ratio, t		-45.79
		(29.63)
Openness, t		29.02
		(24.25)
GDP, t		-1.783
		(1.113)
Country Size		2.178**
		(1.077)
Water/Land		-27.21
		(26.35)
Elevation		-2.223
		(1.475)
Landlocked		0.592
		(3.646)
Temp. Zone Land		3.695
		(6.490)
Africa		3.353
		(2.624)
French Legal Origin		0.295
		(2.778)
Catholics		0.0395
		(0.0398)
Constant	9.950***	34.43*
	(1.425)	(20.24)
Observations	98	83
R^2	0.375	0.527

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

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Table 2.8: Dependent Variable Terms: of Trade Volatility, t=1995

	(1)	(2)
Norm Herf	31.20***	28.75***
	(4.642)	(6.816)
P/Ex Ratio, t		7.202
		(19.78)
Openness, t		-2.311
		(14.11)
GDP, t		-0.128
		(1.240)
Country Size		1.043
		(1.154)
Water/Land		-45.92
		(29.32)
Elevation		-1.251
		(1.578)
Landlocked		2.950
		(4.105)
Temp. Zone Land		-0.656
		(7.240)
Africa		3.701
		(3.012)
French Legal Origin		-0.221
		(3.184)
Catholics		0.0203
		(0.0423)
Constant	10.53***	6.987
	(1.467)	(22.36)
Observations	98	83
R^2	0.320	0.421

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

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Table 2.9: Dependent Variable Terms: of Trade Volatility, t=2000

	(1)	(2)
Norm Herf	27.77***	25.84***
	(4.039)	(6.369)
P/Ex Ratio, t		9.542
		(14.31)
Openness, t		-1.049
		(9.630)
GDP, t		0.236
		(1.079)
Country Size		0.511
		(1.021)
Water/Land		-16.59
		(27.40)
Elevation		-1.647
		(1.469)
Landlocked		6.369*
		(3.693)
Temp. Zone Land		-0.904
		(6.698)
Africa		3.312
		(2.759)
French Legal Origin		0.987
		(2.933)
Catholics		0.0189
		(0.0387)
Constant	10.96***	5.075
	(1.406)	(19.28)
Observations	99	85
R^2	0.328	0.502

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

DOI: 10.2870/22962

Table 2.10: Dependent Variable Terms: of Trade Volatility, t=1987

	(1)	(2)	(3)	(4)
NPC(s=0.01), t	-0.723		-1.991**	
	(0.655)		(0.915)	
FDNPC1, t	-0.0274**		-0.0110	
	(0.0118)		(0.0184)	
NPC(s=0.025), t		-0.156		-2.993*
		(1.124)		(1.764)
FDNPC2, t		-0.0461*		0.00645
		(0.0236)		(0.0397)
Fin Dev, t			-0.0259	-0.0645
			(0.131)	(0.148)
P/Ex Ratio, t			129.9***	137.4***
			(42.74)	(46.48)
Openness, t			-76.82*	-74.12*
			(39.57)	(42.98)
Country Size			2.883*	2.347
			(1.484)	(1.575)
Water/Land			-19.22	-13.39
			(43.79)	(46.62)
Elevation			1.483	1.799
			(2.514)	(2.689)
Landlocked			-3.121	-2.293
			(6.344)	(6.775)
Temp. Zone Land			-4.158	-7.316
			(7.756)	(8.203)
Africa			-7.990	-5.672
			(6.216)	(6.618)
French Legal Origin			3.533	2.464
			(5.020)	(5.469)
Catholics			0.0270	0.0278
			(0.0709)	(0.0769)
Constant	34.69***	29.38***	-2.375	-3.211
	(4.577)	(4.777)	(18.48)	(19.48)
Observations	83	83	78	78
R^2	0.143	0.063	0.431	0.353

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

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Table 2.11: Dependent Variable Terms: of Trade Volatility, t=1990

	(1)	(2)	(3)	(4)
NPC(s=0.01), t	-0.857		-3.521***	
	(0.664)		(0.944)	
FDNPC1, t	-0.0156		0.0292	
	(0.0111)		(0.0273)	
NPC(s=0.025), t		-1.098		-5.816***
		(1.166)		(1.557)
FDNPC2, t		-0.0225		0.0698*
		(0.0182)		(0.0382)
Fin Dev, t			-0.321	-0.449*
			(0.260)	(0.231)
P/Ex Ratio, t			131.0**	123.2**
			(49.28)	(50.42)
Openness, t			-98.70*	-75.94
			(50.89)	(51.49)
Country Size			2.919*	2.552*
			(1.514)	(1.522)
Water/Land			-52.40	-34.85
			(54.48)	(55.95)
Elevation			3.825	4.302
			(2.565)	(2.680)
Landlocked			-9.401	-10.07
			(6.251)	(6.486)
Temp. Zone Land			-2.191	-3.298
			(10.88)	(11.15)
Africa			-4.307	-3.346
			(6.141)	(6.451)
French Legal Origin			-0.287	-0.926
			(5.741)	(5.818)
Catholics			0.0934	0.0688
			(0.0941)	(0.0958)
Constant	34.24***	32.13***	-2.319	-2.764
	(4.802)	(4.998)	(20.34)	(20.09)
Observations	73	73	67	67
R^2	0.101	0.069	0.511	0.481

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table 2.12: Dependent Variable Terms: of Trade Volatility, t=1995

	(1)	(2)	(3)	(4)
NPC(s=0.01), t	-0.378		-3.451***	
	(0.698)		(1.043)	
FDNPC1, t	-0.0126		0.0491*	
	(0.00994)		(0.0268)	
NPC(s=0.025), t		-0.355		-5.389***
		(1.087)		(1.592)
FDNPC2, t		-0.0203		0.0759*
		(0.0184)		(0.0400)
Fin Dev, t			-0.437*	-0.365*
			(0.233)	(0.194)
P/Ex Ratio, t			73.65	87.48*
			(44.91)	(44.78)
Openness, t			-45.34	-51.36
			(40.15)	(40.47)
Country Size			2.312	2.472
			(1.618)	(1.610)
Water/Land			-27.67	-36.64
			(54.89)	(54.56)
Elevation			3.989	3.116
			(2.751)	(2.787)
Landlocked			-8.636	-7.701
			(6.900)	(6.832)
Temp. Zone Land			-9.701	-8.664
			(11.98)	(11.64)
Africa			-4.657	-0.201
			(6.537)	(6.762)
French Legal Origin			-2.628	-1.488
			(6.187)	(6.094)
Catholics			0.0810	0.108
			(0.0935)	(0.0951)
Constant	29.44***	27.77***	2.060	-1.635
	(4.833)	(4.504)	(21.43)	(20.65)
Observations	73	73	67	67
R^2	0.051	0.034	0.388	0.393

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

DOI: 10.2870/22962

Table 2.13: Dependent Variable Terms: of Trade Volatility, t=2000

	(1)	(2)	(3)	(4)
NPC(s=0.01), t	-0.647		-3.270***	
	(0.694)		(0.891)	
FDNPC1, t	-0.00699		0.0343**	
	(0.00845)		(0.0160)	
NPC(s=0.025), t		-0.261		-4.009***
		(1.022)		(1.332)
FDNPC2, t		-0.0164		0.0479*
		(0.0166)		(0.0275)
Fin Dev, t			-0.312*	-0.245*
			(0.156)	(0.129)
P/Ex Ratio, t			89.77***	97.00***
			(26.26)	(27.35)
Openness, t			-36.10	-31.76
			(23.29)	(24.07)
Country Size			1.461	1.285
			(1.434)	(1.476)
Water/Land			-5.967	13.97
			(51.07)	(53.05)
Elevation			3.480	3.142
			(2.454)	(2.567)
Landlocked			-2.354	-0.576
			(5.942)	(6.089)
Temp. Zone Land			-5.234	-6.490
			(11.15)	(11.57)
Africa			-2.870	-2.379
			(5.793)	(6.055)
French Legal Origin			-3.607	-1.961
			(5.691)	(5.918)
Catholics			0.129	0.108
			(0.0888)	(0.0962)
Constant	30.75***	27.62***	7.001	1.071
	(4.772)	(4.336)	(18.68)	(18.70)
Observations	74	74	68	68
R^2	0.048	0.025	0.529	0.495

Standard errors in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

DOI: 10.2870/22962

CHAPTER 3

STICKS AND STONES: A THEORY OF POINT RESOURCES AND APPROPRIATION

3.1 Introduction

This paper aims to contribute to the growing literature of theoretical models dealing with "conflict and appropriation". Although the first general equilibrium model of this type was presented in the overlooked work Haavelmo (1954), it is not until Hirshleifer (1988,1989) that a concerted effort really came together in this field[1][2]. This paper extends the model found in another important contribution, Grossman and Kim (1996), which was the first paper to combine two important facets of general equilibrium conflict models. Firstly, the incorporation of private production shifted focus away from the models of an appropropriable, common pool resource, as described by Hirshleifer (1989) and Skaperdas (1992) among others. Secondly, the distinction between predation and defense against predation that enables a non-aggressive, yet not fully disarmed, equilibrium[3]. In this paper, a parameter representing the *pointiness* of the resource endowment of each agent is included in the model and of key interest is the effect that this parameter has on the conditions for non-aggressive equilibrium. Further, the analysis of Grossman and Kim (1996) shows that a relatively rich agent is always better off in equilibria with more secure claims to property yet if offensive weapons are highly effective and appropriation is not overly destructive, then a relatively poor agent could be better off in equilibria with less secure claims to property. Thus the analysis of this paper also covers the effects of pointiness on the costs of appropriation and on agents' welfare, both individually and relatively.

The term pointiness, in this paper, will used to characterise two key aspects of the resource endowment. One of the dimensions along which the *pointiness* of resources can be classified is the geographical concentration of their means of production. The pointier a given

[1]See Garfinkel (1990), Grossman (1991), Skaperdas (1992), Esteban and Ray (1999), Wittman (2000), and Mehlum et al. (2003) for other key contributions.

[2]See Garfinkel and Skaperdas (2006) for a detailed overview of the literature of conflict economics.

[3]The distinction is first made by Skogh and Stuart (1982), but the possibility of a non-aggressive equilibrium is not considered.

Mott, Graham (2010), Essays in Economic Development
European University Institute DOI: 10.2870/22962

resource, the more clustered its means of production. Thus, resources may be distinguished by geographical grouping, point resources (such as oil wells or ore/mineral mines) that are extracted from a geographically narrow base are distinct from diffuse resources, which are (more thinly) spread across a wider area, such as agricultural land or forests. The other dimension of pointiness that this paper proposes is the mobility of resource. Resources that are less cumbersome, easier to transport and generally more 'mobile' are defined as being more pointy. These two aspects of the characteristic of pointiness are important in a model of appropriation and defense. Similar resources may differ in their means of production and thus, their level of pointiness (alluvial diamonds in comparison to mined diamonds) or differing resources may be produced in similar clusterings (alluvial diamonds in comparison to plantation crops).

The overall consensus within the growth literature is that there exists a negative relationship between development indicators and the pointiness of resources[4][5]. It has been widely suggested that pointy resources can fuel inequality within societies as, being geographically clustered, it is more probable that these resources are controlled by smaller groups, excluding others[6][7]. An extension of this argument is to propose that pointiness is likely to be at important factor when agents are rent seeking. Auty (2001) argues that pointier resources, having more geographically concentrated modes of production and thus revenues and rents, may be more easily appropriable or promote certain groups or agent types. In particular, a government having control over an exogenous form of revenue, in the form of point resources, has much less need to extract revenues from the populace in the form of taxation state and so has much less inclination to develop the institutions that are associated with developed states, resulting in the state falling behind (see Ross (2001). In cases such as this, taxation of non-resource sectors will be low, modes of accountability poor and with frequent violent coups occuring (see Auty (1997), Woolcock et al. (2001), Isham et al. (2003), Murshed (2004), Mavrotas et al. (2006)).

However, it should also be noted that there is strong evidence to suggest that the relationship between resources and conflict intensity is not unambiguous; indeed that there may exist a non-monotonic between the two. This implies that there are cases in which more

[4]Bulte et al (2005) investigates the links between welfare and resource pointiness and abundance.

[5]For a more extensive survey of the literature on the effects on natural resource abundence, see van der Ploeg (2010).

[6]For further details of resource-based gangs, paramilitaries and warlords, see Reno (1998) and Le Billon (2001).

[7]For more detailed work on point resources and inequality, see Ross (1999), Engerman and Sokoloff (2000), Ross (2004b) and Isham et al. (2005).

 DOI: 10.2870/22962

pointy resources may be less heavily contested, to the extent that no conflict occurs at all, or that the presence of pointy resources during intense conflict can coordination a more rapidly achieved peaceful outcome. Wick and Bulte (2006) uses a model with a standard contest success function and interprets the *decisiveness/effectiveness* parameter as the pointiness of the contestable resource. Analysis of the model shows that under certain conditions, a comparison of agents' behaviour either side of a given threshold indicates that increased pointiness can imply a reduction in rent seeking effort. The model presented in this paper describes a similar effect, that the influence of the pointiness of the resource on the level of appropriative activity in non-monotonic, due to increased pointiness being at the same time beneficial to the defender (as a pointier endowment is easier to defend) and the attacker (as pointier resources are subject to lower levels of appropriative destruction). The overall effect of increased pointiness on appropriative behaviour depends on which of these two effects prevails.

The multiple effects of resources on conflict intesity is consistent with the findings of Ross (2004), which describes the observable effects of nine hypotheses concerning the influence of natural resources on civil wars. The findings of the examination of thirteen case studies show that each instance may be explained by one or a number of the hypothesised mechanisms, which themselves may influence differing aspects of the conflict; initiation, intensity and duration[8]. Ross (2004) states that "*resources do not necessarily make conflicts longer or more severe - at times they appeared to shorten conflicts and promote cooperation among opposing sides.*" Further, Bennet and Stam (1996) finds that international conflicts have a tendency to last longer when the sides have more equal resources. As weaker side gains resources, the conflict is lengthened but as the stronger side gains resources, the conflict will be shorted. Therefore, if the stronger agent engages in resource appropriation, conflict becomes more decisive and victory (or settlement) will be brought about more quickly. If agents are more equal then conflict will be lengthened, as the duration of the conflict will be determined by the net outflow of resources from the weaker agent. In the later analysis presented in this paper, the issues of appropriative behaviour, costs and welfare are addressed in the context of hetergenously pointy resource endowments.

The remainder of the paper is organised as follows; section two sets out the model and derives allocations to defense and appropriation, section three provides furher analysis in the context of costs and welfare, section four provides case study evidence of the applicability of

[8]Fearon (2001) also finds that the relationship between resources and civil wars is more complex than previously thought, resource dependence is associated with the duration, but not incidence, of civil wars.

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European University Institute DOI: 10.2870/22962

the model and section five concludes.

3.2 The Model

3.2.1 Set-up of the model

The following model is an extension of that presented in Grossman and Kim (1995)[9]. In a one period model there exists two agents, each agent having an initial positive resource endowment, n_i where $i = 1, 2$. Endowments are classified as non-overlapping claims to property that is subject to appropriation by the other agent and can therefore be thought of as private property[10]. The security of claims to private property, i.e. the strength of property rights, is a represented by an endogenously determined variable. Each agent may allocate proportions of the initial endowment to three rivalrous uses; defence, appropriation and the production of a non-contestable consumption good. Sequentially, each agent first chooses a level of initial endowment to commit to defending its own endowment against appropriative actions of the other agent. In doing so, the agent also considers the value of defensive fortifications as a deterrent to appropriation. Thus, agent i, where $i = 1, 2$, allocates an amount, h_i, to defensive fortifications from its initial endowment, n_i, subject to constraint $0 \leq h_i \leq n_i$. Once made, the defence allocation, h_i, is irreveribly committed by the agent for the entire duration of period, i.e. the defensive investment may not be diverted into production or appropriation in the case of the other agent choosing not to engage in appropriative behaviour. Next, the remainder of the endowment, $n_i - h_i$, is divided by the agent between productive and appropriative uses, where k_i is the amount allocated to productive capital and g_i to appropriative capital (offensive weapons) subject to $k_i \geq 0$, $g_i \geq 0$ and $k_i + g_i = n_i - h_i$. The production process, which is assumed to be independent for each agent, produces consumable goods that are themselves not subject to appropriation by the other agent[11]. The production function of agent i is given by $f(k_i) = \alpha k_i$, where α is a positive productivity parameter. After the complete allocation of the initial endowment and the production of consumable goods, the entire endowment of agent i, regardless of allocation, can potentially be appropriated by the other agent. Thus, one agent can capture another's productive capital, defensive fortifications and offensive weapons but not the output of consumable goods. The security of a given agent's claim to their

[9] In aspects of the model not including the parameter γ, analytical structure directly follows Grossman and Kim (1995).

[10] It terms of the aims and direction of this paper it is perhaps easier to consider the initial endowment as fungible capital.

[11] Both of these assumptions are made in order to simplify the model.

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endowment is demonstrated by the fraction of its own endowment that the agent is able to retain. Specifically, agent i retains a fraction of its own endowment, p_i, where

$$p_i = \frac{1}{1+x_i}, \qquad x_i = \frac{\theta}{\gamma_i}\frac{g_j}{h_i} \tag{3.1}$$

In the above equations, x_i measures the offensive strength of agent j in relation to the defensive strength of agent i, θ is a positive parameter that indicates the effectiveness of offensive weapons against defensive fortifications and γ_i is a measure of the pointiness of the fungible capital of agent i. Further, if $\gamma_i < \gamma_j$ then this implies that the endowment of agent i is more diffuse than the endowment of agent j. The parameter γ is considered as continuous and finite. From equation (4.6), it can be seen that p_i is a decreasing function of x_i and $0 \leq p_i \leq 1$. Also, due to the possibility of asymetric pointiess of endowments and the distinction between offensive weapons and defensive fortifications, the proportion of endowment, p_i, retained by agent i can be greater than, equal to, or less than the fraction of endowment that agent j loses, $1-p_j$. The relative effectiveness of offensive weapons, θ, may be affected either positively or negatively by technological innovations. The development of cannon[12] or the innovations in castle design by Master James of St. George[13] provide examples of each. It may also be seen that p_i, briefly abstracting from any indirect effects, is an increasing function of γ_i. This follows as the more pointy an endowment, the easier it is for an agent to defend and the security of the agent's claim to property is stronger. For example, a mine shaft (pointy) will be easier to defend that a forest (more diffuse) or alternatively, valuable minerals (pointy) will be easier to protect from appropriation than timber (more diffuse). In other general equilibrium models where conflict occurs over a common pool resource, a Contest Success Function (CSF) is specified to determine the extent of victory[14]. Here the CSF for agent j is simply given by $1-p_i$.

This model allows for a destructiveness in appropriation, so that in appropriation the aggressor gains less than the defender loses. Specifically, agent i loses the fraction of its endowment, $1-p_i$, yet agent j gains only the fraction $(1-\frac{\beta}{\gamma_i})(1-p_i)$ of the endowment

[12]By the 15th Century, the development of cannon had revolutionised European siege warfare throughout Europe. Previously, thick castle walls were used to deter would-be aggressors but were now rendered obsolete by heavy cannon fire. Further, see Chartrand, R (2005)

[13]Master James of St. George was a stonemason, engineer and architect responsible for designing many of the Edwardian castles in North Wales, including Conwy, Harlech and Caernarfon. Further, see Taylor, A.J. (1950)

[14]For an overview of contest success functions, see Skaperdas (1996).

DOI: 10.2870/22962

of agent i. The parameter β measures the destructiveness of predation[15], $0 \leq \beta \leq 1$. For example, endowment seized through appropriation is subject to destruction due to conflict, deterioration during shipment or a predator's gain needs to be processed to be usable. However, the destructive nature of appropriation is somewhat negated by the pointiness of the contested resource, γ_i. The pointier the endowment, the less is the net destruction due to appropriation. It is easier transport or process, but harder to denigrate, diamonds than timber for instance. It is assumed that the pointiness of any given endowment is larger than the rate of destruction associated with appropriation, $\gamma > \beta$. Thus, the focus of this paper is on the collection of commodities/endowments that are sufficiently pointy such that the net rate of gain by the appropriating agent is positive i.e. $1 - \frac{\beta}{\gamma} > 0$. It must be noted however that this model does predict that there is a range of endowment pointiness, for all γ such that $1 - \frac{\beta}{\gamma} < 0$, for which the other agent will choose not to engage in appropriative behaviour. This behaviour is induced by the fact that the endowment is so diffuse that the appropriating agent is unable to appropriate/gather/process the endowment without incurring costs that would ultimately prove to be prohibitively high.

The net result of the allocative activities of both agents is that agent i has a final non-negative endowment wealth, m_i, where

$$m_i = p_i n_i + (1 - \frac{\beta}{\gamma_j})(1 - p_j)n_j \tag{3.2}$$

The objective of each agent is to maximize the sum of its production of consumable goods and its net endowment wealth, denoted by v_i, where

$$v_i = \alpha k_i + m_i \tag{3.3}$$

The fundamental trade-off an agent faces is that devoting a higher amount of its initial endowment to appropriation, rather than to the production of non-contestable consumable goods, decreases that agent's output, αk_i, but increases the agent's final wealth, m_i.

3.2.2 Resource Allocation: Offensive Weapons

In order to analyse the allocation of the initial endowment, the model is solved backwards by first considering the choice, between productive capital and offensive weapons, made by the agent in the second-stage. At this stage, agent i takes the defensive allocations made by both agents, h_i and h_j, as given and chooses allocations to productive capital, k_i, and

[15]Note the simplifying assumption that the same parameters, α, β, and θ, apply to both agents.

DOI: 10.2870/22962

to offensive weapons, g_i, such that the agent maximises the net sum of its final assets, v_i, subject to the constraints $k_i \geq 0$, $g_i \geq 0$, and $k_i + g_i = n_i - h_i$. The constraint $k_i \geq 0$ is assumed not to be binding, i.e. that agent i would not want to allocate a negative amount to productive capital ($k_i < 0$) or, equally, to allocate more its initial endowment towards appropriation ($g_i < n_i$). Thus, it follows that the marginal cost of offensive weapons is given by α, the constant marginal product of capital in the production sector. Equations (4.6), (4.7) and (4.8) imply that either v_i has an interior maximum at a positive value of g_i that satisfies

$$\frac{dv_i}{dg_i} = -(1 - \frac{\beta}{\gamma_j})\frac{dp_j}{dg_i}n_j - \alpha = 0, \quad g_i > 0 \tag{3.4}$$

or that v_i is maximized with

$$\frac{dv_i}{dg_i} = -(1 - \frac{\beta}{\gamma_j})\frac{dp_j}{dg_i}n_j - \alpha \leq 0, \quad g_i = 0 \tag{3.5}$$

The above conditions state that if agent i chooses a positive allocation of resources to appropriative activities, then this allocation is such that the marginal cost of offensive weapons equals the marginal benefit (the increased amount of the endowment of agent j that agent i obtains). Alternatively, if agent i chooses not to allocate any resources to appropriative activities, then at the point $g_i = 0$, the marginal cost of offensive weapons equals or exceeds the marginal benefit. By deriving dp_j/dg_i from equation (4.6), we see that the above conditions imply that

$$g_i = \begin{cases} \sqrt{(\gamma_j - \beta)\frac{h_j n_j}{\theta\alpha}} - \frac{\gamma_j h_j}{\theta} > 0 & \text{for } 0 < h_j < h_j^* \\ 0 & \text{for } h_j \geq h_j^* \end{cases} \tag{3.6}$$

where

$$h_j^* = (1 - \frac{\beta}{\gamma_j})\frac{\theta}{\alpha\gamma_j}n_j \tag{3.7}$$

In equation (4.2), h_j^* is the minimum necessary allocation to defensive fortifications by agent j that will deter agent i from allocating any resources to appropriation. Specifically, if $h_j < h_j^*$, then equation (3.4) applies; whereas if $h_j \geq h_j^*$, then equation (3.5) applies. Furthermore, h_j^* depends positively with the initial endowment of agent j and the effectiveness of offensive weapons against defensive fortifications and depends negatively on the marginal productivity of capital and the destructiveness of appropriation. The effect of the level of

DOI: 10.2870/22962

pointiness of the endowment of agent j on the minimum necessary defensive allocation for deterrance is less clear. There is a negative effect as the pointier the resource endowment of agent j, then the easier it is for agent j to defend his endowment and the lower the level of resources needed to achieve the same level of security. This is apparent from equation (4.6). Conversely, there is a positive effect insofar as the destruction to the gain from appropriation by agent i is lower given a pointier resource, which is demonstrated by equation (4.7). The gain from appropriation is now higher for agent i, who will now be willingly to commit more resources to appropriative activities. In order nullify this reallocation, agent j must present a larger deterent in order to disincentivise appropriative activities by agent i and hence, the minimum necessary defensive allocation for deterrance must be higher. The parameters of the model determine which of these two effects dominate. Specifically if $\gamma_j > 2\beta$, then the first effect dominates, a marginal increase in pointiness aids the defender (through easier defence) more than the aggressor and the derivative, $dh_j^*/d\gamma_j$, is negative. Equally, if $\gamma_j < 2\beta$, then the second effect dominates, a marginal increase in pointiness aids the aggressor (through increased gains) more than the defender and the derivative, $dh_j^*/d\gamma_j$, is positive. The closer the value of endowment pointiness is to the critical value, 2β, the higher the allocation to defensive fortifications necessary to ensure non-aggression from agent i. Furthermore, it can be seen that for any $\gamma_j < \beta$, then the defender would wish to invest a negative amount in defensive fortifications[16]. The endowment of this agent is so diffuse that the other agent would have no interest in engaging in appropriative behaviour. This clarifies the statement above, that there exists a range of very diffuse resources, outside of the general workings of this model, for which the optimal behaviour of the other agent would be non-aggression.

3.2.3 Resource Allocation: Defensive Fortifications

Next, the first-stage choice of defensive fortifications is considered. At this stage, the allocation to defensive fortications, h_i, by agent i is take as given by agent j, who chooses defensive fortifications, h_j, to maximize the sum of final assets, v_j. When choosing the allocation to defensive fortifications, agent j takes into account how this choice affects the allocation to offensive weapons, g_i, by agent i. Given the schedule for the allocation to offensive weapons by agent i set out in equation (4.11), equation (4.8) implies that, in the limit as $h_j \to 0$, dv_j/dh_j becomes infinite and so the constraint $h_j \geq 0$ can be taken as not binding. Further, it is assumed that the constraints $h_j \leq n_j$ and $k_j \geq 0$ will not be

[16]Note the assumption in the previous subsection, $\gamma_{i,j} > \beta$

binding[17]. As in Grossman and Kim (1996), the existence a non-aggressive equilibrium, and the conditions necessary to ensure that equilibrium, are of particular interest. In order for agent i to make no allocation to offensive weapons, the parameters of the model must be such that agent j chooses an allocation to defensive fortifications equal to the threshold level, h_j^*. Furthermore, with agent i making no allocation to offensive weapons, the security of property claims of agent j are completely secure, $p_j = 1$. As such equation (4.8) implies that the sum of the final assets of agent j, v_j, is a decreasing linear function of that agent's allocation to defensive structures, h_j. Then, from equation (4.8) it can be seen that v_j has an interior maximum at a value of h_j that satisfies

$$\frac{dv_j}{dh_j} = (\frac{dp_j}{dh_j} + \frac{dp_j}{dg_i}\frac{dg_i}{dh_j})n_j - \alpha = 0, \quad \text{with } 0 < h_j < h_j^* \tag{3.8}$$

or that v_j is maximized at $h_j = h_j^*$ with

$$\frac{dv_j}{dh_j} = (\frac{dp_j}{dh_j} + \frac{dp_j}{dg_i}\frac{dg_i}{dh_j})n_j - \alpha > 0, \quad \text{with } \; h_j = h_j^* \tag{3.9}$$

The above equations demonstrate that if agent j chooses a defensive allocation less than the threshold, then this allocation is such that the marginal benefit and cost of defensive fortifications are equal, where the marginal benefit of defensive allocation includes both a direct effect of the allocation on the security of claims and an indirect effect of the same relationship, via the deterent effect of the defensive allocation on the offensive allocation of agent i. Alternatively, if agent j chooses a defensive allocation less than the threshold, the marginal benefit of defence exceeds the marginal cost. Substituting for dp_j/dh_j, dp_j/dg_i and dg_i/dh_j from equations (4.6) and (4.11), we see that equations (3.8) and (3.9) imply that

$$h_j = \begin{cases} \frac{\gamma_j^2 n_j}{4(\gamma_j - \beta)\theta\alpha} < h_j^* & \text{for } 2(\gamma_j - \beta)\theta > \gamma_j^2 \\ h_j^* & \text{for } 2(\gamma_j - \beta)\theta \leq \gamma_j^2 \end{cases} \tag{3.10}$$

The above specification describes the equilibrium allocation to defensive fortifications by agent j. Equation (4.1) demonstrates that the level of defensive fortifications depends negatively on the production parameter and on the effectiveness of offensive weapons and positively on the level of appropriation destruction and size of the endowment of defending agent, n_j. The relationship between the level of defensive fortifications and the pointiness of the endowment of the defender is dependent on a threshold level of pointiness, 2β. For any $\gamma_j < 2\beta$, then exists a positive correlation betwen the two, whilst the opposite is true

[17] This implies that the marginal cost of defensive fortifications is also α.

for any $\gamma_j > 2\beta$.

The threshold that determines the nature of the equilibrium strategy of the agent, whether it is characterised by appropriation or non-aggression, is given by the relationship between $2(\gamma_j - \beta)\theta$ and γ_j^2. The more effective that are offensive weapons and the less destructive that is appropriation, then the more likely that the equilibrium strategy will be characterised by agent j engaging in appropriation. As the inequality is quadratic in γ_j, a marginal increase in the level of pointiness makes a non-aggressive strategy more likely only on the condition that $\theta < \gamma_j$. For cases in which offensive weapons are more effective, relative to the pointiness of the endowment, the same marginal increase moves the models towards, or reinforces, an appropriative strategy. It is important to note that the threshold in the model need not be unique. As stated previously, for any value of endowment pointiness less than the value of the appropriative destruction parameter, i.e. $\gamma_j < \beta$, the potential appropriator cannot realise a positive gain, due to net destruction, and non-aggression is enforced. If appropriative destruction is high and offensive weapons are not very effective[18], then a non-aggression strategy by the potential appropriator may continue to be optimal for a range of diffuse endowments, $\hat{\gamma}_j \epsilon [\beta, \gamma^*]$, subject to $2(\hat{\gamma}_j - \beta)\theta = \hat{\gamma}_j^2$. The possible spectra of optimal strategies, for differing levels of pointiness, arising in the model are discussed in the following subsection.

3.2.4 Security of Claims to Property

The equilibrium allocation to offensive weapons, g_i, is found by combining equations (4.1) and (4.11).

$$g_i = \begin{cases} \frac{\gamma_j}{2\theta\alpha}\left[1 - \frac{\gamma_j^2}{2(\gamma_j - \beta)\theta}\right] n_j & \text{for } 2(\gamma_j - \beta)\theta > \gamma_j^2 \\ 0 & \text{for } 2(\gamma_j - \beta)\theta \leq \gamma_j^2 \end{cases} \tag{3.11}$$

In the above specification, it can be seen that if agent j attains the minimum necessary defensive allocation for deterrance, h_j^*, which occurs when $2(\gamma_j - \beta)\theta \leq \gamma_j^2$, then agent i does not commit any resources to offensive weapons, $g_i = 0$. However, if $2(\gamma_j - \beta)\theta > \gamma_j^2$, then agent j will make an allocation to defensive fortifications, such that $h_j < h_j^*$, and agent i will appropriate. Thus, g_i will be positive and proportionate to the size of the endowment being appropriated, n_j[19]. Furthermore, if $g_i > 0$, the second term in the square bracket in equation

[18] Further, β must be high and θ must be low relative to each other.

[19] See Appendix A for the necessary conditions so for that for both agents, and for all variations of pointiness as described in section three, $h + g \leq n$

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(3.11) is proportional to the defensive allocation of agent j and so for $\gamma_j < 2\beta$, a marginal increase in pointiness of the endowment will lead to an increase the appropriative allocation of agent j. Simple algebra shows that the proportional increase in the appropriative allocation by agent i is greater than the proportional decrease of the defensive allocation of agent i. If a region exists such that $\sqrt{2(\gamma_j - \beta)\theta} > \gamma_j > \beta$, the more effective are offensive weapons and the more diffuse the contested endowment then the more likely that agent i increases appropriative allocation in response to a marginal increase in the pointiness of the contested endowment.

By combining equations (4.1), (3.11) and (4.6), the equilibrium value of the security of claims to endowment can be found

$$p_j = \min\left[1, \frac{\gamma_j^2}{2(\gamma_j - \beta)\theta}\right] \tag{3.12}$$

In the above equation, if $2(\gamma_j - \beta)\theta \leq \gamma_j^2$, then the defensive allocation of agent j is sufficient to act as an effective deterent, agent i choose not allocate any endowment to appropriation and the claims to property of agent j are fully secure, with $p_j = 1$. Otherwise, the endowment of agent i is too diffuse, offensive weapons too effective or appropriation not destructive enough for agent j to be able to deter appropriative activity by agent i. As appropriation is not effectively detered, claims to property are less than fully secure. Again, recognise that the security of claims to property with appropriation is proportional to the defensive allocation of agent j and so for $\gamma_j < 2\beta$, there is a negative correlation between the pointiness of the endowment and the security of claims to property of agent j. Also, note the equilibrium value of the security of claims is independent of the size of endowments, which follows as both h_j and g_i are both portionate to the size of the endowment. As the parameters α, β and θ are assumed to be identical for both agents, this implies that agents have identical security of claims to property if and only if both agents are endowed with equally diffuse resources.

Depending on the values of the parameters for appropriative destruction and effectiveness of offensive weapons, the space $\beta < \gamma_j \leq \gamma^{\max}$ may be characterised by one, two or three distinct regions of optimal strategy. The quadratic nature of the threshold condition rules out the sequence of regions, for increasing values of pointiness, of appropriation - non-aggression - appropriation, otherwise the sequence of optimal strategy is fully determined by the two parameters (θ and β). Indeed, for very low values of appropriative destruction and/or very effective offensive weapons the entire strategy space, $\beta < \gamma_j \leq \gamma^{\max}$, may be characterised by appropriation. The opposite also holds true. Further, as the strategy

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space may consist of three regions, non-aggressive regions for relatively diffuse or pointy endowments and an appropriative region for averagely pointy/diffuse endowments, it can be seen that the same, non-appropriative behaviour may be induced in each agent for very different endowment types. Agents need not hold homogenous resource endowments in order for a non-appropriative equilibrium to be sustained. This is a unique finding in the sense that the strategy space is not completely characterised by non-aggresion. For this organisation of the optimal strategy space, the non-aggressive equilibrium may not be stable if the agents, in a theoretical sense, were to move towards homogeneity at an average 'pointiness' of their endowments.

Thus, this model shows that the relationship between conflict and pointiness of resources may take on many forms, forms are (mostly) determined by other parameters specified within the model. Whereas Wick and Bulte (2006) theorises a non-monotonic relationship where, given certain conditions increased pointiness may lead to a reduction in rent seeking, this finding shows that the relationship may more more complex than. Furthermore, this complexity would seem to be constistent with the findings of Ross (2004) and may help to explain the existence multiple outcomes observed from situations of resource abundance.

3.3 Further Analysis

In the following analysis, and given that the other parameters of the model (α, β and θ) are identical for both agents, three types of equilibrium are possible.

Firstly, an appropriative equilibrium occurs when the resource endowments of the agents are such that $2(\gamma_i - \beta)\theta > \gamma_i^2$ and $2(\gamma_j - \beta)\theta > \gamma_j^2$, so neither agent finds it optimal to invest in defensive fortications to the extent of completely detering the other agent from engaging in appropriative activity. Both agents allocate a positive level of endowment to offensive weapons, so $g_i, g_j > 0$, and claims to property will be less than fully secure, with $p_i, p_j < 1$. The levels of endowment pointiness which sustain this equilibrium are denoted $\gamma_{i,A}$ and $\gamma_{j,A}$[20].

Secondly, a non-aggressive equilibrium in which the resource endowments of the agents are such that $2(\gamma_i - \beta)\theta \leq \gamma_i^2$ and $2(\gamma_j - \beta)\theta \leq \gamma_j^2$, so both agents find it optimal to invest the minimum necessary allocation to defensive fortifications to completely deter appropriative activity by the other agent. Both agents make no allocation to offensive weapons, $g_i, g_j = 0$ and claims to property will be fully secure, $p_i, p_j = 1$. The levels of endowment pointiness

[20] Thus, agent j with endowment characterised by $\gamma_{j,A}$, induces $h_j < h_j^*$, $g_i > 0$ and $p_j < 1$.

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which sustain this equilibrium are denoted $\gamma_{i,N}$ and $\gamma_{j,N}$[21]

Lastly, a mixed equilibrium in which the endowment of one agent is characterised by γ_A and the other has an endowment characterised by γ_N . Thus, the latter engages in appropriative behaviour whilst the former does not and the latter has completely secure claims to property whilst the former does not. The following section discuss these scenarios in the context of the total costs of appropriation and agent welfare.

3.3.1 The Cost of Appropriative Activities

The total cost of appropriation[22] is given by

$$c_{i,j} \equiv \alpha(h_i + h_j + g_i + g_j) + (\beta/\gamma_i)\,(1 - p_i)n_i + \left(\beta/\gamma_j\right)(1 - p_j)n_j \tag{3.13}$$

Firstly, agents suffer an opportunity cost of appropriation and defense as a result of diverting proportions of their endowments towards defensive structures and offensive weapons and away from productive capital. This cost is equivalent to $\alpha(h_j + g_j + h_i + g_i)$. Secondly, there is a cost associated with the destructiveness of appropriation, endowment that is completely lost to both agents, equivalent to $(\beta/\gamma_i)\,(1 - p_i)n_i + \left(\beta/\gamma_j\right)(1 - p_j)n_j$. Equations (4.1), (3.11) and (3.12) can be used to show that total costs depend on the parameters θ, β, γ and the endowments of the agents. In a non-aggression equilibrium, agents do not incur any costs related to appropriative destruction and so total costs depend only on the opportunity cost of each agent.

$$c_{N,N} = \sum_{z=i}^{j} \left(1 - \frac{\beta}{\gamma_{z,N}}\right) \frac{\theta}{\gamma_{z,N}} n_z \tag{3.14}$$

where $c_{N,N}$ specifies the strategies of each agent (non-aggression, non-aggression). In this case, equation (3.14) demonstrates that the cost for each agent is directly proportional to their allocation to defensive fortifications, such that $c_z = \alpha h_z^*$ as above. Therefore, the correlations between agents' costs and the parameters of the model follow the same relationships as under the derivation of the minimum necessary allocation to defensive for deterence, h_j^*.

Under an appropriative equilibrium, agents incur both an opportunity cost and a cost related to appropriative destruction. Equation (3.15) indicates that the total cost, $c_{A,A}$, is no longer monotonically related to the effectiveness of offensive weapons, θ, or to the

[21] Thus, agent j with endowment characterised by $\gamma_{j,N}$, induces $h_j = h_j^*$, $g_i = 0$ and $p_j = 1$.

[22] NB Total cost refers to the society as a whole.

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destructiveness of appropriation, β. However, as noted by Grossman and Kim (1996), for equilibria with relatively high security of claims to property, i.e. as $p \to 1$, a monotonic and negative relationship emerges between p and c. Accordingly, in the model presented here, changes in θ, γ or β that increase p reduce the cost associated with appropriation and dominate any offsetting effect created by foregoing the production of consumables. Therefore, for a sufficiently secure claims, there exists a negative correlation between pointiness and total costs.

$$c_{A,A} = \sum_{z=i}^{j} \left[\frac{\beta}{\gamma_{z,A}} + \frac{\gamma_{z,A}}{\theta} \left(1 - \frac{(\theta + \gamma_{z,A})\gamma_{z,A}}{4\theta \left(\gamma_{z,A} - \beta \right)} \right) \right] n_z \tag{3.15}$$

Further analysis of equations (3.14), (3.15) shows that costs in a non-aggressive equilibrium are not unconditionally lower than costs in an appropriative equilibrium, i.e.there are pairings of parameters for which $c_{N,N} \not> c_{A,A}$. However, this is only true for appropriative costs functions derived from parameterisations of the model that result in 'appropropiation' being the optimal strategy for entire space, $\beta < \gamma_j \leq \gamma^{\max}$. This follows intuitively as the entire strategy space is only characterised by appropriation when appropriative destrustion is very low and/or offensive weapons are very effective, i.e. when net appropriate costs are very low.

Total costs for a mixed equilibrium, in which agent i has a endowment with pointiness $\gamma_{i,A}$ and agent j has a endowment with pointiness $\gamma_{j,A}$, are given by (3.16)

$$c_{N,A} = \left[\frac{\beta}{\gamma_{i,A}} + \frac{\gamma_{i,A}}{\theta} \left(1 - \frac{(\theta + \gamma_{i,A})\gamma_{i,A}}{4\theta \left(\gamma_{i,A} - \beta \right)} \right) \right] n_i + \left(1 - \frac{\beta}{\gamma_{j,N}} \right) \frac{\theta}{\gamma_{j,N}} n_j \tag{3.16}$$

Agent j invests in a sufficient defensive fortification so that agent i chooses not to appropriate. However, agent i cannot optimally do the same, given a resource endowment charactised by pointiness $\gamma_{i,A}$. Therefore, the size of the endowment of agent i influences the opportunity cost of defence for agent i, the opportunity cost of offence agent j and the loss to appropriative destruction whereas the size of the endowment of agent j influences the opportunity cost of defence for agent j. It should be noted that although higher costs may be attributed to the appropriating agent, the transfer of wealth from the defender to the aggressor is not included in total 'social' cost but will obviously affect the final net assets of each agent. Welfare is discussed in the following subsection.

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3.3.2 The Welfare Effects of Appropriation

The welfare of each agent is measured by the sum of production of consumables and net endowment flows, v_i and v_j, as given by equation (4.8) Of particular interest the relationships between welfare and the parameters γ, θ and β and the conditions under which the welfare of an agent is higher in any non-aggressive equilibrium than in any equilibrium characterised by claims to property that are not fully secure. By combining equations (4.8), (4.1), (3.11)[23], (4.7) and (3.12)[24], the welfare of each agent may be derived.

For non-aggressive equilibria, when the endowments are characterised by $\gamma_{i,N}$ and $\gamma_{j,N}$, the welfare of agent i is given by

$$v_i = (1+\alpha)\, n_i - \left(1 - \frac{\beta}{\gamma_{i,N}}\right) \frac{\theta}{\gamma_{i,N}} n_i \tag{3.17}$$

Equation (3.17) demonstrates the negative correlation between welfare and the opportunity cost of defensive provision, as outlined in equation (3.14). Therefore, in an equilibrium characterised by non-appropriation, the relationship between the parameters of the model and the welfare of agent i is the inverse of the relationship between these parameters and the total costs borne by agent i, as outlined above. Further, unless the endowments of the agents are identical, in terms of pointiness and size[25], then the welfare of the two agents will differ, $v_i \neq v_j$. It may be the case that the agent that begins the period as the richer agent bears, relatively or absolutely, the higher costs (as the endowment is larger to defend or level of pointiness of the endowment that implies a higher deterrence requirement). Therefore, the possibly exists of the initially richer agent becoming the poorest by the end of the period, i.e. if $n_i > n_j$ but $v_i < v_j$. Thus, a non-aggressive equilibrium may not necessarily preserved the 'social ordering', despite an absence of appropriative activity.

For appropriative equilibria, when the endowments are characterised by $\gamma_i = \gamma_{i,A}$ and $\gamma_j = \gamma_{j,A}$, the welfare of agent i is given by

$$v_i = \left[\alpha + \frac{\gamma_i^2}{4\theta\left(\gamma_i - \beta\right)}\right] n_i + \left[1 - \frac{\beta}{\gamma_j} + \gamma_j \frac{4\theta\left(\gamma_j - \beta\right) - \gamma_j^2}{4\theta^2\left(\gamma_j - \beta\right)}\right] n_j \tag{3.18}$$

In appropriation characterised equilibria, v_i, like the total cost function c, is not necessarily monotonically related to γ, θ or β. Further, the welfare of agent i depends not only on the initial endowment of agent i but also on the initial endowment of agent j, so the

[23] Equations (4.1) and (3.11) are used to give the equilibrium value of k_i.

[24] Equations (4.7) and (3.12) are used to give the equilibrium value of the net final endowment wealth, m_i.

[25] The analysis abstracts from the case in which $\gamma_{i,N} \neq \gamma_{i,N}$ but $h_i^* = h_j^*$.

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relationships between v_i and γ, θ and β depend on the relative size of the initial endowment of agent i relative to that of agent j. As with the cost function, it is not always the case that agents are always better off in a non-aggressive equilibrium that in an appropriative equilibrium.

In mixed equilibria, if it is assumed that agents have endowments characterised by $\gamma_i = \gamma_{iA}$ and $\gamma_j = \gamma_{jN}$, then the welfare agent i (the non-aggressive agent) is given by

$$v_i = \left(\alpha + \frac{\gamma_i^2}{4\theta(\gamma_i - \beta)}\right) n_i \tag{3.19}$$

whereas the welfare of agent j (the appropriating agent) is given by

$$v_j = (1+\alpha)\, n_j - \left[\left(1 - \frac{\beta}{\gamma_j}\right)\frac{\theta}{\gamma_j} + \gamma_j A_j\right] n_j + \left(1 - \frac{\beta}{\gamma_i}\right) A_i n_i \tag{3.20}$$

where

$$A_i = \left(\frac{2\theta(\gamma_i - \beta) - \gamma_i^2}{2\theta(\gamma_i - \beta)}\right) \tag{3.21}$$

and

$$A_j = \left(\frac{2\theta(\gamma_j - \beta) - \gamma_j^2}{4\theta^2(\gamma_j - \beta)}\right) \tag{3.22}$$

Due to the plethora of equilibria possible, it is difficult to make generalisations regarding relative welfare of the agents. Grossman and Kim (1996) conclude, more generally, that if agent i is relatively rich, then the economic welfare of agent i is higher the more secure are claims to property i.e. that the richer agent prefers less effective offensive weapons and higher appropriative destruction. However, the richer agent in this model may favour lower values of appropriative destruction and more effective offensive weapons if the result of the change in parameters is a gain in appropriable endowment that outweighs any increase costs of defence (which is possible due to varying levels of endowment pointiness between agents). Likewise, less secure claims to property do not necessarily serve to increase the welfare of a relatively poor agent. The rich will only favour conditions that encourage universally secure claims to property if there are no 'easy pickings' to be had and the poor only favour weaker claims to property if it does not make themrelatively easy prey. Thus, the ambiguous, non-monotonic effects of endowment pointiness in this model may contradict the more straight-forward results presented in Grossman and Kim (1996).

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3.4 Case Studies

The mechanisms outlined in this model are clearly apparent in two contemporary cases, outlined more extensively in Ross (2004), of the Democratic Republic of Congo and Sierra Leone.

3.4.1 Democratic Republic of Congo, 1996

During the 1980s and early 1990s, the Democratic Republic of Congo (DRC) experienced a steady change to small-scale, alluvial mining from large-scale, deep shaft mining. In terms of the model presented in this paper, this shift equates to a reduction in the pointiness of the endowment, γ. In the case of the former, small teams of unskilled workers can extract diamonds from the accessible, softer soils of the upper layers of an (expansive) alluvial plains. The latter, however, requires the use of heavy, technical equipment within a more confined geographical areas in order to reach diamonds that may be several hundreds metres underground, encased within other rocks or minerals. Indeed, the fact that diamonds are encased in this way and would, therefore, need to be carefully processed in order to maximise payoff, serves to increase the destructiveness of appropriation parameter, β.

According to MacGaffey (1991), this structural change helped to create small military units, which were independent from the central government, which flourished in this industry, forming rackets and selling protection to the small-scale miners. It was also common for miners to form collectives in order to ensure their own self-defense units. Furthermore, DRC military units became involved in the trade in primary resources and arms, in order to become self-financing. Reno (1998) notes of cases in which military generals sold protection to alluvial miners and of generals using military units to transport primary commodities, often internationally. It is very likely that these activities, weakening of government military forces and privateer protection of miners and mining facilities/areas, contributed to a considerably weaker overall defence of the natural resources of the DRC. In terms of the model, this equates to a decrease in the level of defensive fortifications, h.

The model presented in this paper would suggest that this combination of changes in key variables would lead to a higher incentive for any outside agent to engage in appropriative behaviour against the DRC. Indeed, there is strong evidence to support the theory that these were the fundamental factors that encouraged rebel groups, led by the Rwandan and Ugandan armies, to initiate the war in 1996. The UN Panel of Experts (2001) reports that agents within both Rwanda and Uganda were keen to profit from the appropriation of the natural resources of the DRC, in part as a means to offset the cost of the attack.

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3.4.2 Sierra Leone, 1991

The case of Sierra Leone very much mirrors that of DRC, outlined above. The alluvial diamond fields were controlled by fragmented groups of privateer gangs and rogue military groups that organised protection for the agents within the small-scale industry[26]. As such, the government's military forces and it's influence within the region became weakened. Reno (1998) documents an attempt by the government, in 1991, to re-assert authority over the region that led to the displacement of thousands who subsequently joined rebel groups, in particular the Revolutionary United Front (RUF). In this case, government forces had been steadily weakened resulting in lower defense capabilities, h, and rebel groups had become better armed in quality and quantity (increasing θ and g) due to the recruitment of displaced paramilitaries and privateers. As stated above, alluvial diamonds can be considered a less pointy resource than mined diamonds, which may be considered as an incentive for an appropriative agent. It is these factors, and the abrupt changes in many of these factors, that the presented model argues contribute to the initiation of conflict. These factors may have been fundamental in the decision of Liberia's Charles Taylor to become involved in the civil war. In addition, the proximatey of the alluvial fields to the Liberia-Sierra Leone border and the difficulty of tracing the source of conflict diamonds[27] serves to reduce the parameter β in the presented model, further incentivising appropriative actions.

As an aside, the anaylsis of Ross (2004) rules out the hypothesis of the Collier-Hoeffler "looting" mechanism as being an underlying cause of any the thirteen conflicts under discussion, including the two above. However, analysis of these two cases in the context of the model presented in this paper would appear to give weight to the looting mechanism argument. In particular, lower pointiness of resource endowments lead to a rise (or strengthening) of organized predation, a willingness to take advantage of more easily available rents.

3.5 Conclusions

This paper has extended the general equilibrium model of appropriation and production as presented in Grossman and Kim (1996). The model presented here includes a parameter to represent the pointiness of the contended resource endowment, where the pointiness of a resource is defined along the dimensions of the geographical concentration of its means of production and its mobility. A higher level of endowment pointiness has two functions in the

[26] For further details, see Hirsch (2001) and Richards (1996).

[27] For more on the issue of tracing conflict diamonds and the Kimberley Process, see Olsson (2007).

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model, which oppose each other in terms of determining equilibrium outcome. Firstly, point resources are easier to defend than diffuse resources, thus aiding the defender. However, point resources are also subject to lower (net) levels of apppropriative destruction, thus incentivising the appropriating agent. It is these opposing effects that create the non-linearities that are key to the results presented here.

The findings presented here demonstrate that the relationship between resource pointiness and conflict may take on many forms. Depending on the parameterisation of the model, the agents' strategy space $\beta < \gamma_j \leq \gamma^{\max}$ may be characterised by one, two or three distinct regions of optimal strategy, of which only one strategy schedule along this space is ruled out. It is also shown that agents need not hold homogenously pointy resource endowments in order for non-aggressive or appropriative equilibrium to be sustained, grreatly varying resource endowments may induce the same type of behaviour in both agents. Whereas Wick and Bulte (2006) theorises on the existence of a non-monotonic relationship where, given certain conditions, increased pointiness may lead to a reduction in rent seeking the model presented here suggests that this is only one of a number of possible relationships. Furthermore, this complexity would seem to be constistent with the findings of Ross (2004) and may help to explain the existence multiple outcomes observed from situations of resource abundance.

This paper has also demonstrated that costs in an non-aggressive equilibrium may not always be lower than in any appropriative equilibrium, in contrast to the results of Grossman and Kim (1996). If appropriative destruction is very low and offensive weapons are very effective then the costs of appropriation are very low and the whole strategy space is characterised by appropriate behaviour. It is only in these circumstances that an appropriative equilibrium mayhave lower total costs than a non-aggressive equilibrium. In terms of welfare, it was demonstrated that a non-aggressive equilibrium may not necessarily preserved the 'social ordering', despite an absence of appropriative activity. Further, the rich will only favour conditions that encourage universally secure claims to property if there would be no relatively 'cheap' targets created as a result of weaker security of claims. Likewise, the poor may not automatically favour weaker claims to property.

There are a number of potentially interesting extensions to this paper, both theorectical and empirical.

Firstly, the development of a dynamic model in which the end of period, net assets of the agent (v) would serve as the initial resource endowment of the next period. Of particular interest would be cases in which pointiness of agents' endowments differed, potentially causing

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agents to switch from non-aggressive agents to appropriators (and potentially back again) as resources ebb and flow between agents. If analysis of wealth and wealth distribution is analysed, questions regarding the incentivising of peace be addressed. Under what conditions can peace be brokered rather than continuous, appropriative destruction ending in Easter Island style collapse? Further, the model (dynamically or statically) many be enriched by the inclusion of a greater number of agents or endowments consisting of a greater number of resources than there are agents.

In terms of empirical extensions, an application to specific case studies would provide validation of the model. Given adequate sources of data, a full calibration of the model may be possible in order to test the results presented here.

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3.6 Appendix A

Following Grossman and Kim (1996), from (4.1) and (3.11) the necessary conditions for $h+g \leq n$ for any given agent may bed derived. In the case of an appropriative equilibrium, agents have endowments characterised by levels of pointiness $\gamma_i = \gamma_{iA}$ and $\gamma_j = \gamma_{jA}$, the necessary condition for agent i is given by:

$$\alpha \geq \frac{\gamma_i^2}{4(\gamma_i - \beta)\theta} + \frac{\gamma_j}{2\theta}\left[1 - \frac{\gamma_j^2}{2(\gamma_j - \beta)\theta}\right]\frac{n_j}{n_i} \tag{3.23}$$

As agents' endowments are not necessarily homogenous, this imples a corresponding necessary condition for agent j. Thus, both necessary conditions must be fulfilled in order for the equilibrium to exist. In the case of a non-aggressive equilibrium, agents have endowments characterised by levels of pointiness $\gamma_i = \gamma_{iN}$ and $\gamma_j = \gamma_{jN}$, the necessary condition for agent i is given by:

$$\alpha \geq (1 - \frac{\beta}{\gamma_i})\frac{\theta}{\alpha\gamma_i} \tag{3.24}$$

Again, there is a corresponding necessary condition for agent j and both necessary conditions must be fulfilled in order for the equilibrium to exist. In the third case, of a mixed equilibrium, if it is assumed that agents have endowments characterised by $\gamma_i = \gamma_{iN}$ and $\gamma_j = \gamma_{jA}$, then the necessary condition for agent i is given by

$$\alpha \geq (1 - \frac{\beta}{\gamma_i})\frac{\theta}{\alpha\gamma_i} + \frac{\gamma_j}{2\theta}\left[1 - \frac{\gamma_j^2}{2(\gamma_j - \beta)\theta}\right]\frac{n_j}{n_i} \tag{3.25}$$

Agent j will not engage in appropriative behaviour and the corresponding necessary condition is given by

$$\alpha \geq \frac{\gamma_j^2}{4(\gamma_j - \beta)\theta} \tag{3.26}$$

Again, both necessary conditions must be fulfilled in order for the equilibrium to exist.

Mott, Graham (2010), Essays in Economic Development
European University Institute DOI: 10.2870/22962

CHAPTER 4

THE KIDS AREN'T ALRIGHT: CHILD MORTALITY AND THE PERSISTENCE OF CHILD LABOUR

4.1 Introduction

A large proportion of the previous literature on the subject of child labour, and indeed the literature concerning intergenerational transmission of inequality and its persistence as a whole[1], have identified failures in capital markets as a key factor in the persistence of intergenerational child labour within poorer households[2]. Some works, such as Baland and Robinson (2000), have, however, demonstrated that child labour may persist in poorer households if the returns education are low, even with perfect credit markets whilst others discuss the role played by human capital externalities[3]. Chakraborty and Das (2005) abstacts from capital markets and identifies a distinct mechanism which, operating through endogenous adult mortality risk, reduces the effective return to children's education for poorer households, thereby contributing to the persistence of child labour. There is no altruistic link between successive generations. Children are treated solely as a source of current and future income by young parents. During childhood, offspring contribute to their parent's income by working (when not being educated) and as adults, they provide pension-like support to old-aged parents through transfers dictated by cultural norms. The key demographic variables of fertility, health investment and education are all decided by parents[4]. Endogenous mortality is captured by specifying a positive relationship between the probability with which a parent survives into old age and health investment. Essentially, this implies a positive relationship between income level and the rate of time preference. Lawrence (1991) and Samwick (1998) provide strong empirical evidence supporting this hypothesis. Thus, endogenous mortality may play a fundamental role in changing the incentives of relatively poor parents and creating child labour traps.

[1] See for example Banerjee and Newman (1993), Galor and Zeira (1993), Aghion and Bolton (1997), Ghatak and Jiang (2002), Mookherjee and Ray (2002, 2003)

[2] See Basu (1999) and Ranjan (2001),

[3] See Galor and Tsiddon (1997).

[4] Duraisamy (2002) shows that parental preferences play an important role in decisions regarding children, such as education.

Mott, Graham (2010), Essays in Economic Development
European University Institute DOI: 10.2870/22962

This paper presents a discrete time, overlapping generations model that extends Chakraborty and Das (2005) by including a child survival function. Therefore, the model allows for the possibility of the child dying between childhood and adulthood or more specifically, that a child may die before attaining any of the benefits of the educational investment that the child has received. Previous works have addressed the issue of child mortality and parent choice. Cigno (1998) and Blackburn and Cipriani (1998) endogenise child survival probability by making child mortality subject to parental decision and these papers, along with Olsen and Wolpin (1983), suggest that at low levels of development, parents optimally choose high levels of child mortality. More recently, Doepke (2005) quantitatively addresses the issue of child labour in a Barro-Becker framework with exogenous child mortality.

The remainder of the paper is organised as follows; section two sets out the model and derives solutions, section three provides analysis in the context of policy and section four concludes[5].

4.2 The Model

4.2.1 Outline and Survival Functions

This paper is an extension of the model of Chakrborty and Das (2005)[6]. In the discrete-time, overlapping-generations model presented here, individuals can potentially live for three periods; "childhood", "adulthood" and "old-age". The individual survives, with certainty, for the entire first period of life whereas survival into adulthood and then further into old-age is uncertain and depends upon the level of health investment, h_t, made by the young parent. Young parents have children at the beginning of the period as well as making all household decisions at this time.

The parameter ϕ_t describes the probability of the young parent surviving into old-age where the functional form is given by

$$\phi(h_t) = \left(\frac{h_t}{1+h_t}\right)^{\eta} \tag{4.1}$$

where $0 < \eta < 1$. Thus, the survival function of the young parent is a twice differentiable, concave function and if a young parent chooses not to invest anything in healthcare, then

[5]I thank Agnese Leonello for her patient assistance with some of the computational aspects of this paper.

[6]In aspects of the model not including the parameter θ_t, analytical structure directly follows Chakrborty and Das (2005).

they die before old age with certainty[7]. The probablity of a child's survival into adulthood is denoted as θ_t and is also dependent on the health investment taken by the parent of the child, h_t. Health investment by the young parent, h_t, is not just a personal investment but has direct effects for the entire household. The child survival function is specified as:

$$\theta(h_t) = \left(\frac{h_t}{1+h_t}\right)^{\psi} \tag{4.2}$$

where $0 < \psi < \eta$. The child's survival function, like that of the young adult, is twice differentiable and concave with respect to health investment. It is assumed that health investment is more effective, in terms of survival, for children than adults as children are more frequently and to a larger degree more susceptable to disease and illness. Further, children do not have the built-up immunity to many diseases and illnesses that may been acquired by adults. Thus, it is considered that health investment is fundmentally more important to a child's survival probability.

4.2.2 Work and Education

In each period, individuals are endowed with a single unit of time. Children divide their time between work and school, whilst young parents divide their time between raising children and work. The old-age individuals only consume a proportion of wealth, α, transfered to them from the gross income of any surviving children. For each child that a young parent chooses to raise, a 'cost' is incurred as the parent is required to devote a proportion of time, τ, to childcare. Thus, for given number of offspring the parent chooses to issue, n_t, there remains a total time available to the young parent for work of $1 - \tau n_t$. Work consists of the production of a perishable consumption good using labour supplied by those in adulthood (young parents) and, possibly, their children. Output per efficiency unit of labour, or the wage, is given by ω.

The initial young generation are born at $t = 0$ with a given distribution of human capital $\{e_i^0\}$. A young parent decides on the health invest of the family, the number of offspring, whether or not to send their children to work and how much to educate them. Young parents are only differentiable from each other by their levels of educational capital, e_{t-1}^t. As well as the allocation of their own time, young parents decide the allocation their children's time. Children may either be sent to work, in order to increase the income of the household during that period, or to school, in order to receive an education and increase their future labour

[7] That is $\phi_t = \phi(h_t), \phi(0) = 0, \phi_t' > 0, \phi_t'' < 0$

productivity. Child are sent to school for a fraction of their time endowment, $e_t \in [0,1]$, whilst all the time not spent in school is spent working, such that $l_t = 1 - e_t$. Therefore, labour productivity of a young parent is given by $1 + e_{t-1}$ but education is not assumed to increase the productivity of the child. Further, it is assume that children are less productive than an uneducated adult[8], such that the output of a working child is $(1 - e_t)\,\gamma$ where γ is productivity parameter associated with children, such that $\gamma < 1$. As the child's education decision by the young parent is akin to the education decision, as child may only work or go to school, parents face a trade off between current and future consumption. Increased current consumption is a result of increased child labour participation, lower school participation and so implies lower future consumption, as young adults who have received less educated have lower productive capabilities and provide lower transfer payments.

4.2.3 Utility

At date t, a representative young parent maximizes their expected lifetime utility over contempory and future personal consumption, (c_t^t, c_{t+1}^t),

$$u\left(c_t^t\right) + \beta\phi_t u\left(c_{t+1}^t\right) \tag{4.3}$$

where β represents the subjective discount rate, where $\beta \in [0,1]$. It is assumed that utility derived from death is zero and no bequests exist between parent and child. Utility is a twice differentiable, concave function rate within this model. In effect $\beta\phi_t$ represents an endogenously determined discount rate. Further, note that there is no altruistic mechanism linking successive generations of the household. Children are regarded as a source of current and future consumption by self-interested parents and transfers to the older generation are assumed to be governed by social convention.

In total a young parent makes three choices (health investment, fertility and children's education investment) and in doing so faces the following budget constraints:

$$c_t^t = \gamma\omega\left(1 - e_t\right)n_t + \left(1 - \alpha\right)\omega\left(1 + e_{t-1}\right)\left(1 - \tau n_t\right) - h_t \tag{4.4}$$

$$c_{t+1}^t = \alpha\theta(h_t)\omega\left(1 + e_t\right)n_t \tag{4.5}$$

[8] *Children in preindustrial Europe gradually drifted into work from around the age of seven or eight. Much of their labor was casual and undemanding, for they were not strong enough to take on most of the tasks required on a farm or in a workshop.* Heywood (2004)

where n_t represents the fertility choice of the young parent, with $n_t \geq 1$.

The budget constraint for the young parent is written under the assumption that the grandparent is alive in period t and that child mortality rates are taken into account directly. We focus on this case with loss of generality. The Kuhn–Tucker necessary and sufficient first-order conditions for the young parent's choice variables $(h_t; n_t; e_t)$ are given by:

$$u'\left(c_t^t\right) = \beta\phi'\left(h_t\right) u\left(c_{t+1}^t\right) + \alpha\beta\bar{\omega}\left(1+e_t\right) n_t\phi_t\theta'(h_t)u'\left(c_{t+1}^t\right) \tag{4.6}$$

$$\left[(1-\alpha)\left(1+e_{t-1}\right)\tau - \gamma\left(1-e_t\right)\right] u'\left(c_t^t\right) \geq \alpha\beta\theta_t\phi_t\left(1+e_t\right) u'\left(c_{t+1}^t\right) \tag{4.7}$$

$$\gamma u'\left(c_t^t\right) \geq \alpha\beta\theta_t\phi_t u'\left(c_{t+1}^t\right) \tag{4.8}$$

From equation (4.7), it can be seen that, at an interior optimum, the marginal rate of intertemporal substitution has to be at least as large as the return to the quantity of children, R_t^n.

$$\frac{u'\left(c_t^t\right)}{\beta\phi_t u'\left(c_{t+1}^t\right)} \geq \frac{\alpha\left(1+e_t\right)\theta_t}{(1-\alpha)\left(1+e_{t-1}\right)\tau - \gamma\left(1-e_t\right)} \equiv R^n$$

The numerator signifies the expected incxrease in old-age consumption as a result of an additional child; a product of the contribution rate α, the child's future education-augmented productivity $(1+e_t)$ and the child's survival probabilty θ_t. The denominator represents the associated cost of that child; foregone adulthood earnings net of the child's labour income.

Also, from equation (4.8), it can be seen that young parents will educate their children as long as the marginal rate of intertemporal substitution is at least as large as the return to education. That is

$$\frac{u'\left(c_t^t\right)}{\beta\phi_t u'\left(c_{t+1}^t\right)} \geq \frac{\alpha\theta_t}{\gamma} \equiv R^e$$

In the above inequality, the return to education is given by the ratio between the marginal contribution of a child's education to old age income and the productivity of child labour. Note tht both of the inequalities presented above are dependent on the child survival function but not on the survival function of the young adult. Naturally, a quantity/quality trade-off occurs, the result of which depends on the relationship between the two returns. If the return to education dominates, such that $R^e > R^n$, then a young parent will act to maximise the quality of offspring over and above the quantity of offspring. Thus, the young parent

DOI: 10.2870/22962

minimises the number of offspring, so $n_t = 1$, and the child receives a strictly positive level of education, $e_t > 0$. Conversely, if the return to the quantity of children dominates, $R^n > R^e$, the young parent has numerous children ($n_t > 1$) but does not invest in their education ($e_t = 0$) and therefore children are required to work for the entirety of their available time ($l_t = 1$)[9]. It can be seen from the two returns that young parents will prioritise quantity of offspring over quality of offspring when:

$$e_{t-1} < \bar{e} = \frac{2\gamma}{(1-\alpha)\tau} - 1 \tag{4.9}$$

If the education capital of the young parent is below a given threshold, $\bar{e}$, this implies quantity investment in children will take place[10]. Child labour productivity (γ) and the proportion of labour income transfered from young adults to old parents (α) are both positively correlated with the threshold as increases in either of these parameters increase the opportunity cost of educating children, requiring young parents who are relatively 'better off' before education can begin. Raising the cost of each children (τ) naturally lowers the demand for children. Note that this threshold is independent of the child survival function and so does not differ in any from the corresponding threshold of Chakrborty and Das (2005). As education is linked to productive efficiency for young parents, it is when young parents are relatively poor that they will decide to have a greater number of children rather than fewer, but better educated, children.

4.2.4 Solving the Model

In order to investigate the intergenerational dynamics of the model, preferences are specified as a CES utility function:

$$u(c) = c^{1-\sigma}, \quad \sigma \in [0, 1]$$

When returns to education dominate, $R^e > R^n$, the young parent minimises the number of children. Thus, substituting $n_t = 1$ into equation (4.6) and (4.8) and combining under the given CES preferences yields:

[9] *My father has been dead about a year; my mother is living and has ten children, five lads and five lasses.....three lasses go to mill; all the lads are colliers.....I never went to day-school; I go to Sunday-school, but I cannot read or write* - Patience Kershaw, aged 17.
Testimony from British Parliamentary Papers (1842)

[10] Assuming $2\gamma > (1-\alpha)\tau > \gamma$

DOI: 10.2870/22962

$$1 = \frac{\gamma\omega}{(1-\sigma)}\left[\frac{\phi'(h_t)}{\phi(h_t)} + (1-\sigma)\frac{\theta'(h_t)}{\theta(h_t)}\right](1+e_t) \tag{4.10}$$

such that

$$h_t = \frac{\gamma\omega}{(1-\sigma)}\left[\varepsilon_\phi + (1-\sigma)\varepsilon_\theta\right](1+e_t) \tag{4.11}$$

where $\varepsilon_\phi \equiv h\phi'/\phi$ is the elasticity of the young adult survival function and $\varepsilon_\theta \equiv h\theta'/\theta$ is the elasticity of the child survival function. Using the survival functions from equations (4.2) and (4.1), these elasticities are given as:

$$\varepsilon_\phi = \frac{\eta}{h_t+1}, \qquad \varepsilon_\theta = \frac{\psi}{h_t+1} \tag{4.12}$$

The positive relationship between children's education and health investment is, in Chakrabortya and Das (2005), the driver of *the prevalence and persistence of child labour.* Children potentially provide an income for the young parents, in both the adulthood and old-age of those parents. Parents who do not invest in health, thereby decreasing their probability of survival, expect to die earlier and are, therefore, less willing to substitute contemporaneous income and consumption for old-age income and consumption. This is demonstrated by the decrease in the effective discount rate, $\beta\phi(h_t)$. Young parents 'front-load' consumption by sending their children to work rather than to school. It is, therefore, a prerogative of relatively rich parents to invest significantly in health to improve longevity and send their children to be educated.

The mechanism introduced in this paper reinforces this effect. From equations (4.11) and (4.2), it can be seen that there is a positive effective between health investment and child survival, so young parents who are unable to invest in health can expect fewer of their children to survive into adulthood and again, are disincentivised from substituting income and consumption towards old-age. Equations (4.3) and (4.5) may be re-arranged to show that introduction of child mortality effectively reduces the endogenous discount rate, such that it is given by $\beta\phi(h_t)[\theta(h_t)]^{\frac{1}{\sigma}}$. Thus, the introduction of a child survival function effectively lowers the discount rate further than in the model of Chakrabortya and Das (2005).

In the first instance, young parents have disincentives to invest in children of quality if they cannot adequately guarantee their own survival to take advantage of the delayed benefits of the child's education. In the second instance, young parents have disincentives to invest in children of quality if they cannot adequately guarantee their children's survival. As

a result, the relatively worse off young parents prefer to send their children out to work.

Next, combining equation (4.11) and equation (4.8) yields[11]:

$$\left(\frac{\alpha\beta\theta_t\phi_t}{\gamma}\right)^{\frac{1}{\sigma}}\left[\gamma\left(1-e_t\right)+\left(1-\alpha\right)\left(1+e_{t-1}\right)\left(1-\tau\right)-h\left(e_t\right)\right]=\alpha\left(1+e_t\right)\theta_t \tag{4.13}$$

where $h_t \equiv \bar{\omega}h\left(e_t\right)$. This expression describes the intergenerational evolution of education (and thus also the intergenerational evolution of child labour) for families where parental education exceeds the threshold $\bar{e}$, as outlined in equation (4.9). This may be re-arranged such that

$$e_{t-1}=F\left(e_t\right) \tag{4.14}$$

where[12]

$$F\left(e_t\right)=\frac{1}{\left(1-\alpha\right)\left(1-\tau\right)}\left[h\left(e_t\right)-\gamma\left(1-e_t\right)+\alpha\theta_t\left(1+e_t\right)\left(\frac{\gamma}{\alpha\beta\phi_t\theta_t}\right)^{\frac{1}{\sigma}}\right] \tag{4.15}$$

The above equation shows that the addition of child mortality will drive down the level of education a young parent allocates to their child. As the term in child survival is positive and greater than unity, the young parent requires a higher level of education in order to achieve any given positive level of child education, e_t.

Whereas the sufficient condition in Chakrabortya and Das (2005) for $F\left(e_t\right)$ to be increasing and concave is given as $\varepsilon_\phi < \sigma$, the corresponding sufficient condition in this paper is given as a weighed sum of the two survival elasticities, $\varepsilon_\phi + \left(1-\sigma\right)\varepsilon_\theta < \sigma$[13]. From equation (4.10), it can be seen that the weighed derivative terms must be equal to the weighted derivative term of Chakrabortya and Das (2005), for a given level of child's education, e_t,

$$\left[\frac{\phi'\left(h_t\right)}{\phi\left(h_t\right)}+\left(1-\sigma\right)\frac{\theta'\left(h_t\right)}{\theta\left(h_t\right)}\right]^{M}=\left[\frac{\phi'\left(h_t\right)}{\phi\left(h_t\right)}\right]^{CD} \tag{4.16}$$

[11] Disregarding the child survival function, Chakrabortya and Das (2005) erroneously omit the subjective discount rate, β, from the following function.

[12] Disregarding the child survival function, Chakrabortya and Das (2005) erroneously omit the subjective discount rate, β, and the term $\gamma\left(1-e_t\right)$ from this function.

[13] In calculating the sufficient condition, this paper, as in Chakrabortya and Das (2005), abstracts from the secondary effects of child's eduction on the elasticities of survival as they have been shown to have neglible influence.

DOI: 10.2870/22962

Given the conditions that $\sigma \in [0,1]$, $0 < \eta < \psi < 1$ and that the parameter η is identical to both models, the only way in which equation (4.16) holds (and thus by extension equation (4.10)) is that for a given level of children's education the presence of a child mortality risk induces the young parent to make a higher investment into health than under conditions where child survival is certain. Further, from this finding, it can be shown that the first derivative of equation (4.15) is more positive and the second derivative is more negative with the inclusion of child survival than under the conditions of Chakrabortya and Das (2005).

If the sufficient condition is achieved, the function Q is a monotonically increasing transformation such that

$$e_t = F^{-1}(e_{t-1}) \equiv Q(e_{t-1}) \tag{4.17}$$

and so equation (4.14) may be transformed to

$$l_t \equiv q(l_{t-1}) \tag{4.18}$$

for $l_{t-1} \leq 1 - \bar{e}$ and $q(l) \equiv 1 - Q(1-l)$, where q is an increasing concave function.

Suppose, instead of the scenario outlined above, that returns to quantity of children outweigh the returns to quality, $R^n > R^e$, which implies that young parents have relatively low levels of education, $e_{t-1} < \bar{e}$. These parents have numerous children, $n_t > 1$, choose not to educate them, $e_t = 0$, and so these children work full-time, $l_t = 1$. Combining equation (4.6) and equation (4.7) yields:

$$h_t = \frac{[(1-\alpha)(1+e_{t-1})\tau - \gamma]}{(1-\sigma)} [\varepsilon_\phi + (1-\sigma)\varepsilon_\theta] \omega n_t \equiv h(e_{t-1}, n_t) \tag{4.19}$$

In this scenario, there is a positive relationship between human capital investment and the number of offspring[14]. Healthier individuals have a higher likelihood of surviving in old-age and so are more willing to invest in children, by producing more of them, and foregoing present consumption in the form of payment of care costs in order to receive higher contribution from their children during old-age. Combining the above equation with equation

[14] Assuming, as previously, that the marginal cost of raising a child is greater than the immediate return, that is $\tau(1-\alpha) > \gamma$.

(4.7) gives[15]:

$$\left[\gamma + \left[\frac{\gamma + \nu_{t-1}}{\tau}\right]\left(\frac{1}{n_t} - \tau\right) - \frac{\nu_{t-1}}{(1-\sigma)}\left[\varepsilon_\phi + (1-\sigma)\,\varepsilon_\theta\right]\right] = \alpha\theta_t\left(\frac{\alpha\beta\theta_t\phi_t}{\nu_{t-1}}\right)^{\frac{1}{\sigma}} \tag{4.20}$$

where

$$v_{t-1} = (1-\alpha)\,(1+e_{t-1})\,\tau - \gamma$$

Equation (4.20) defines the deterministic relationship between the optimal number of children and the educational capital of the parent, e_{t-1}. Taking families in which parents choose not to educate their children, i.e. where parents possess $e_{t-1} < \bar{e}$[16], it is obvious that the grandchidren of those parents will also remain uneducated, plus the great-grandchildren and so forth, for all future generations eminating from those parents. In these families, the time invariant, optimal fertility rate for any period $t \geq 1$ can be devised from this relationship by setting $e_{t-1} = 0$.

$$n^* = \frac{v}{\tau}\left[\alpha\theta\left(\frac{\alpha\beta\theta\phi}{v}\right)^{\frac{1}{\sigma}} - \gamma + \frac{\left[\varepsilon_\phi + (1-\sigma)\,(1+\varepsilon_\theta)\right]}{(1-\sigma)}v\right]^{-1} \tag{4.21}$$

As can be seen from equation (4.19), health investment will achieve a steady state under these conditions. Further, this implies that both child and adult survival rates will be time invariant rates. Equation (4.21) demonstrates the negative relationship between the optimal number of children, n^*, and the child survival function, θ. When the uneducated young parent is particularly poor, health investment is very low and children are less likely to survive. In order to try and achieve a certain level of old age income, the young parent will produce a greater number of children in the knowledge that fewer will survive into adulthood and the greater numbers of children that will be engaged in full-time work[17]. Young, uneducated parents who face a higher child survival rates optimally choose to have fewer children, aware that more of them will survive to transfer income in the future. Thus, the addition to the model of the child survival function will exacerbate the child labour problem in terms of absolute numbers. Parents who expect a high proportion of their children to die before adulthood have a greater number of them in order fulfil a need for an expected

[15] Disregarding the child survival function and thus setting $\varepsilon_\theta = 0$, Chakrabortya and Das (2005) carry through previous errors, erroneously omit the subjective discount rate (β) and, on the right hand side, give the incorrect sign to the indice of ν_{t-1} from this function.

[16] As set out in equation (4.9).

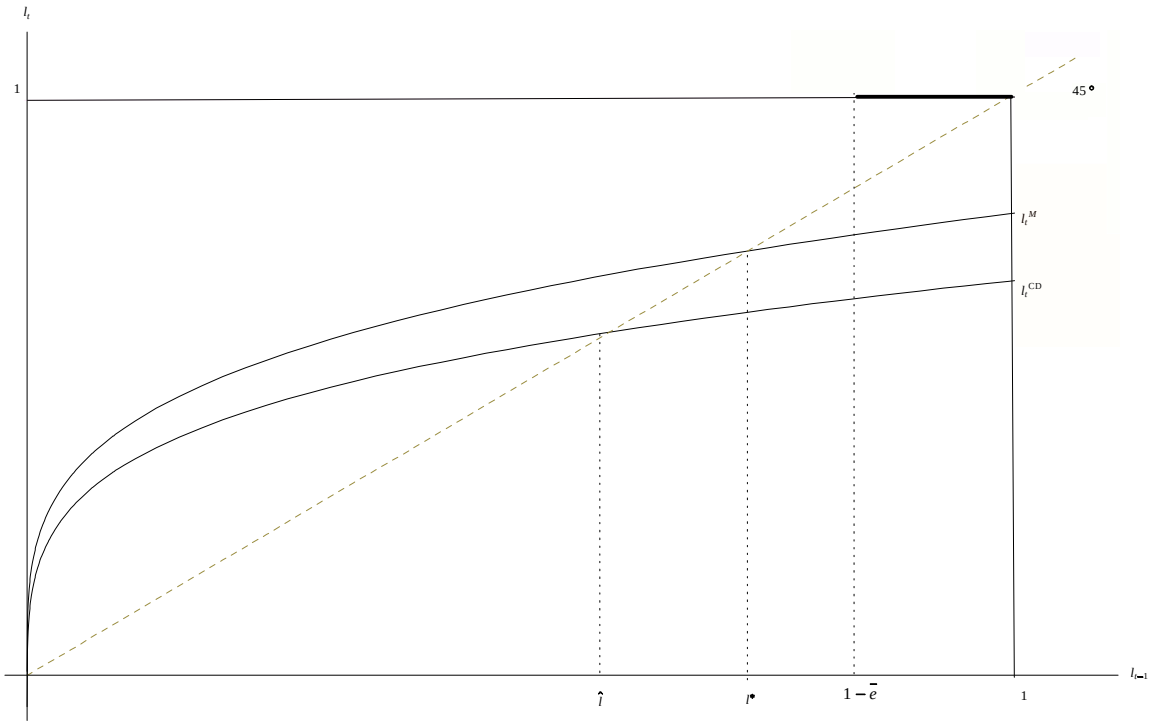
[17] *When women have children thick (fast) they are compelled to take them down early. I have been married 19 years and have had 10 bairns; seven are in life* - Isabel Wilson, 38 years old, coal putter
Testimony from British Parliamentary Papers, (1842)

DOI: 10.2870/22962

income in later life.

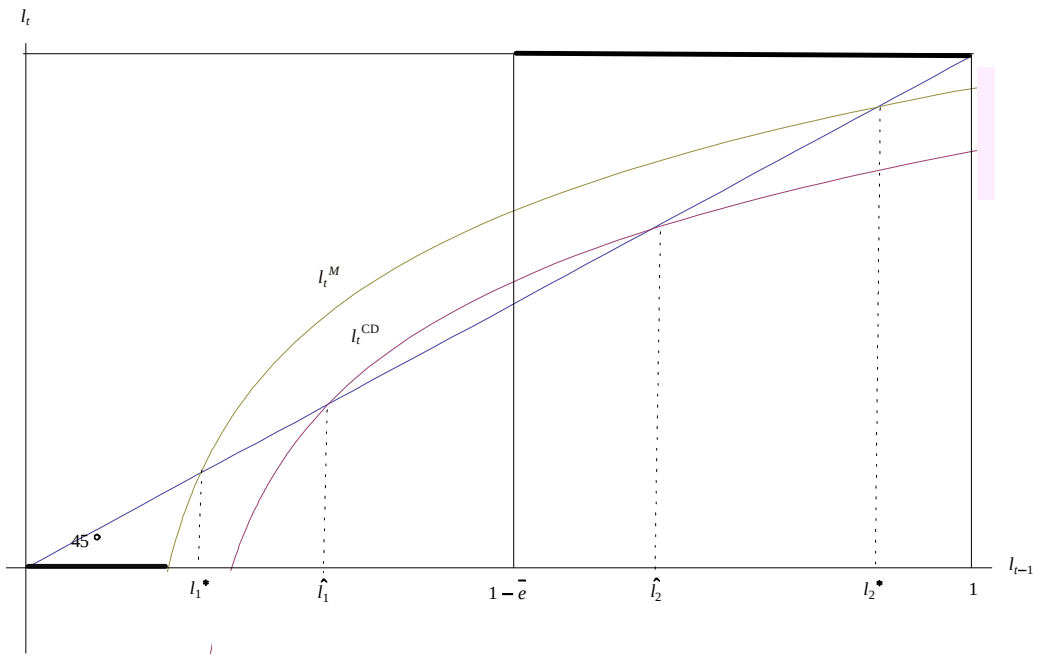
4.2.5 Dynamics of the Model

In discussing the dynamics of child labour, the fundamental aspect of the model is the relation of the initial distribution of education, $\{e_0^i\}$, to the threshold given by $\bar{e}$. For $e_0^i > \bar{e}$, the dynamics of the model are defined by equation (4.18), conditions under which it is possible to achieve multiple steady-states. Both figures presented below exhibit two curves (for differing parameterisations); one given by l_t^M that represents the equation (4.18) presented in this paper and the other, given by l_t^{CD}, as reference of the same schedule as given by Chakrabortya and Das (2005).



In Figure 1, the phase map is given by l_t^M for $l_t \epsilon [0, 1-\bar{e})$ and by $l_t = 1$ otherwise. Two stable steady states occur, at l_1^* and 1, and it can be noted that the stable steady state at full child labour is common to both models, as it occurs after the threshold. Any families with initial education capital less than the threshold, $e_0^i < \bar{e}$, are drawn to this steady state. The second steady state occurs at l_1^* and as $l_1^* > 0$, child labour cannot be 'phased–out' under these conditions. As with the entire phase map before the threshold, $l_t^M > l_t^{CD}$ for a given level of parental labour participation, and so it follows that the steady state that occurs

along l_t^M is such that $l_1^* > \hat{l}$. This steady-state l^* can be seen to occur at a higher level of both adult and child labour participation, and so at lower levels of educational participation, than the corresponding steady state, $\hat{l}$, of Chakrabortya and Das (2005). Further, it may be such that $l_1^* > 1 - \bar{e} > \hat{l}$ and in this case the effect of including child mortality have been to reduce the model from having two stable steady states (one of which exhibits positive levels of education) to a model of a unique, steady state where labour participation is complete. Therefore, the inclusion of child labour makes it much more probable that a household faces an absolute child labour trap, where regardless of initial education endowment, families will converge to a situation where children are fully employed and never educated.



In Figure 2, the phase map is given by $l_t^M > 0$ for $l_t\epsilon < 1 - \bar{e}$ and by the shaded horizontal lines otherwise. The steady states that occur at 0 and 1 are stable, l_1^* is not. If the initial educational distribution of the family, e_0^i, is below the threshold $\bar{e}$, then families converge to the stable steady state of full labour participation and this is the same under both models, as above. However, in order to for a family to converge to the full education steady state, the initial education distribution must be very high, such that $\bar{e} < 1 - l_1^* < e_0^i$. For any initial distribution that does not fulfil this condition, the family will converge to the full labour participation steady state. Thus it may be the case that even if a young parent initially chooses quality over quantity, the poorer households with educational capital below $1 - l_1^*$, are unable to overcome their initial disadvantage, cannot sustain the education of

DOI: 10.2870/22962

their children over successive generations and continue to rely on fully realised child labour participation in the long run.

Further, note that the initial education distribution in the presented model must be higher than in the model presented by Chakrabortya and Das (2005) in order to prevent the family from converging to a full labour participation steady state, i.e. $1 - \hat{l}_1 < 1 - l_1^* < e_0^i$. Thus, the situation again presents itself that in a model with child mortality the educational capital of the young parent must be higher than in a model without child morality in order to achieve the stable steady state that is characterised by a positve level of child's education. It may also be that $l_2^* > 1 - \bar{e} > \hat{l}_2$ and, as above, an additional stable steady would exist in a model without child mortality. However, under this parameterisation an absolute child labour trap cannot occur.

These results demonstrate that the inclusion of a child survival function in the model presented in Chakrabortya and Das (2005) can result in the reinforcement of the parental discounting effect and further encourages the persistence of child labor and under-investment in education in poorer families.

4.3 Policy implications

The findings of this paper demonstrate the importance of setting a range of interconnected objectives in order to tackle the single issue of child labour. High levels of educational spending or trying to enforce primary eduction will have little effect for situations in which health care provision is low and mortality rates are high.

The UN Millenium Development Goals (MDGs) do not mention child labour but directly address the issues that the presented model proposes are fundamental in the decision making process of the young parent. Namely, the MDGs address primary education (Goal 2), child mortality rates (Goal 4), maternal health (Goal 5) and the prevalence of preventable disease (Goal 6). Advances in these particular fields will have a dramatic indirect effect on the levels of child labour and, the model predicts, lower the fertility rate.

Furthermore, it is important that any kind of policy intervention is targetted to ensure resources are being used efficiently. Often, the poorer sections of the population tend to suffer from treatable infections or diseases but public money is often spent on relatively expensive treatments that disproportionately benefit the wealthy. Government health spending towards the rich in the form of cheap healthcare or insurance subsidies. For example, World Bank (1993) notes that the Indonesia Government gave healthcare subsidies to the richest ten

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percent of the population that were nearly three times higher than the subsidies given to the poorest ten percent. Of particular concern should be the targetting of children health. In the analysis above, there exists a coupling of the survival functions due the fact that the two functions are dependent on the same type of spending, household health investment. In reality, these functions may be decoupled as certain types of spending may pertain to one group rather than the other. For example, vaccinations programs are likely to be far more effective at reducing child mortality relative to adult mortality. The opposite is likely true of lung disease treatments or cancer. Both adult mortality and child mortality need to be addressed, as in the MDGs, if child labour is to be greatly reduced.

It is not just the decision variables of the parent that may be targetted in order to reduce child labour. Nardinelli (1990) highlights the fact that, during the 1840s and 1850s, the British silk industry employed a falling proportion of children in its workforce, even though children were not covered by factory legislation during this period. New technologies resulted in the disappearance of factory roles fulfilled by children, which would correspond to a significant decrease in the child's relative productivity parameter, γ. Equation (4.9) demonstrates that a decrease in children's productivity reduces the parent educational threshold required for quality over quantity. Landes (1972) supports this ascertion, that work in more technologically advanced factories "required and eventually created a new breed of worker," a new breed that frequently did not include children. Nardinelli (1990) further suggests rising wages may have enabled working-class parents to keep their children in school for longer, being less relient on any income from child labour. It is interesting to note that in the model presented here, wages (ω) only directly affect health investment levels, as seen in equations (4.11) and (4.19), and it is through health investment that wages indirectly affect education/labour levels and optimal fertility levels, see equations (4.15) and (4.21). Thus, this paper would suggest that rising wages do not reduce child labour by enabling to forego child income but by reducing mortality rates of both parents and children, thus increasing the value of education.

4.4 Conclusions

This paper has extended the discrete time, overlapping generations model of Chakraborty and Das (2005). The model presented here includes a child survival function, where the rate of survival of a child is dependent on the healthcare expenditure of the young parent. The inclusion of this function reinforces the mechanism described in Chakraborty and Das (2005), as child mortality induces an even higher rate of time preference in the young parent. As

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the child may die before the young parent realises the benefit of any educational investment, so education becomes relatively more expensive and the young parent prefers contemporary income from the child rather than an transfer in old age. As has been demonstrated above, any non-binary steady state is associated with higher levels of child labour for the model presented here, erlative to that of Chakraborty and Das (2005), and the introduction of a child survival function may rule out steady states, which are characterised by positive levels of education, that may otherwise exist. Thus, the inclusion of a child survival function into the model serves to reinforce *the prevalence and persistence of child labour*.

Furthermore, it has been shown that these reinforcements may not just be small or subtle. Given certain parameterisations of the model, the inclusion of child mortality may reduction the number of stable steady states in the model. This may result in the 'destruction' of a steady state characterised by 'intermediate' levels of education so that only the initially 'well-endowed' can achieve the high level of stable education. Worse still, the destruction of the only steady state characterised by positive education will result in an absolute child labour trap whereby even families that are initially well educated will converge to a state of absolute child labour.

It has also been shown that under conditions where young parents choose 'quantity' over 'quality' in their fertility decisions, then the inclusion of child mortality increases the number of children a young parent decides to produce. As more children die before adulthood and thus cannot make transfers to their old age parents, young parents choose to have more children in order to ensure similar old age incomes.

This paper has also described the importance of wide ranging but targetted policy aims in order to address the roots of child labour persistence and prevalence. The Millenium Development Goals provide a particularly useful framework.

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