The Spatial Distribution of Economic Activity:

Natural Advantage, Market Access, and Politics

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Abstract

This dissertation addresses the two questions of how economic activity is distributed across space, and what are the factors that determine this distribution. The introductory chapter sets the scene. This is followed by three substantive chapters which cover three different aspects of economic location: the size distribution of cities, factor endowments, and political economy. A final chapter concludes.

Chapter 2 assesses the empirical validity of Zipf's Law for cities, which states that the size distribution of cities follows a Pareto distribution with shape parameter equal to 1. New data on 73 countries is used. We reject Zipf's Law far more often than we would expect based on random chance. Variations in the value of the Pareto exponent are better explained by political economy variables than by economic geography variables.

Chapter 3 explores the relationship between factor endowments, technology, and the location of industrial production, using a panel dataset on Indian industries across states and over time. Factor endowments and technology play important roles in explaining the share of an industry in GDP. This finding is robust to the inclusion of controls for the policy environment and market access. The liberalisation of the economy beginning in 1985 and 1991 represents a clear structural break in the relationship between industry share, factor endowments, and technology.

Chapter 4 develops and tests a political economy model of campaign contributions and electoral competition, extended to consider the implications for factor mobility and hence the structure of production. There are two main predictions. First, countries with more capital stock tend to implement more pro-capital policies. Second, the more different are countries' policies, the more different will be the set of goods which they produce. These predictions are confirmed using panel data on cross-state differences in policies and economic outcomes in India.

Contents

[1] This chapter is based on a paper accepted for publication in *Regional Science and Urban Economics*.

List of Tables

List of Figures

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Chapter 1
Introduction

The revival of interest in economic geography has been largely credited to Paul Krugman's 1991 book *Geography and Trade.* In that book, Krugman develops the idea that, in the presence of increasing returns to scale and transport costs of goods, workers and entrepreneurs have an incentive to locate together, or to use the economists' buzzword, to "agglomerate". This then has implications for the unequal distribution of economic activity across locations.

Yet Krugman was not the first to think about the issue of where economic activity is located. Indeed, the neoclassical trade model developed by Heckscher and Ohlin is essentially a model of the distribution of economic activity, in this case based on factor endowment differences across locations. And finally, in a world where government intervention is part of economic life, the role of politics cannot be discounted as a force for the determination of the location of economic activity.

This dissertation addresses the question of where economic activity is located, and why. The uneven distribution across space of economic activity is a fact of life and one can think of many reasons why this is the case. I focus on three basic ideas: that the location of economic activity can in large part be explained by differences in factor endowments, market access, and policies across locations. These ideas are illustrated in three specific applications: the size distribution of cities, the relationship between factor endowments and the location of industry, and the role of absolute size in influencing policy and hence the structure of production.

In the rest of this introduction, I discuss the three basic ideas underlying the analysis, and give an overview of the rest of the dissertation. Chapter 2 begins the analysis on the size distribution of cities, while Chapter 3 focusses on the relationship between factor endowments, technology, and industrial structure. Chapter 4 shifts the focus to emphasise the role of politics and government policy. Finally, Chapter 5 offers some brief conclusions. In view of the diverse issues addressed here, I do not dedicate a separate chapter to an overall literature review; instead, a literature review is incorporated into the introductory sections of each chapter, to highlight the contributions of that chapter relative to the existing literature.

1.1 Three basic ideas

There are clearly many possible factors that may influence the distribution of economic activity across space. In this dissertation I limit my analysis to three factors which together appear to have the greatest impact: factor endowments, market access, and politics. This section will highlight how these factors are interwoven into the analysis of the following chapters.

Factor endowments refer to the distribution of factors of production. This may include natural resources such as minerals, or man-made resources such as capital stock and skilled labour. Factor endowments have played many important roles in economics. For my purposes, two roles are the most important. First, the neoclassical theory of international trade as developed by Heckscher and Ohlin has emphasised the importance of differences in factor endowments across countries in the determination of industrial structure and hence the pattern of trade (see Flam and Flanders (1991) for a translation of the original contributions by Heckscher and Ohlin). The key result of the Heckscher-Ohlin trade theory is that countries will tend to specialise in the goods which use intensively the factors with which they are (relatively) abundantly endowed. This result emerges most cleanly in the model with two goods and two factors, but holds with appropriate qualifications and modifications when there are larger numbers of goods and factors. As Chapter 3 documents, recent empirical studies which relax some of the stricter assumptions of the standard model, have found a good fit between theory and evidence.

Another way in which factor endowments may impact on the subsequent analysis comes from neoclassical growth theory. Here the seminal article is Solow (1956), who shows that factor accumulation leads to higher levels of per capita income. This theoretical result on factor accumulation and income levels has found empirical support in the results of Mankiw, Romer and Weil (1992). In chapters 2 and 4, the level of per capita income is included in the empirical analysis to capture this effect.

The original idea of market access appears to have come from regional science, in what Fujita, Krugman and Venables (1999) refer to as market potential analysis. The basic idea is intuitively appealing: in the presence of any type of cost of connecting producers to consumers, producers will prefer to locate in areas with many consumers. This idea has formed the basis of formal theoretical modelling by Krugman and others (see especially Krugman (1991), Fujita, Krugman and Venables (1999)), which they refer to as new economic geography.

Theory-consistent empirical validation of this idea can be found in Hanson (1998), Redding and Venables (2004), and Amiti and Cameron (2004), who find that access to markets and suppliers play important roles in determining differences in income levels across locations. Overman, Redding and Venables (2003) survey this and older evidence on the role of proximity to markets, while Harrigan (2003) has a section discussing the persistent success of the gravity equation as a predictor of trade flows between countries. In my analysis, direct measures of the variables used in models of new economic geography are included in the analysis in Chapter 2, while measures of market access are used in Chapter 3.

Finally, there is the role of politics. In the absence of market failures and with a benevolent social planner, the planner's outcome simply replicates the competitive outcome. However, since in reality there are market failures, diverse special interest groups and social planners who are not always benevolent, state intervention in the economy has the potential to yield outcomes that are very different from market outcomes. This line of research is most closely associated with the work of Persson and Tabellini (2000) and Grossman and Helpman (1994, 2001), who characterise the equilibria that emerge when political agents are self-interested agents. The alternative theories relating politics to trade policy are surveyed in Helpman (1997), while empirical evidence as surveyed by Gawande and Krishna (2003) tends to be supportive of the impact of politics on economic outcomes, although the details of the evidence do not always agree with the theories.

Politics plays an important part in all of the following chapters. In Chapters 2 and 3, political histories and government policies are used as part of the empirical exercise, while Chapter 4 develops a political economy theory of capital mobility and industrial structure, and proceeds to empirically test the predictions of the model.

1.2 Three levels of analysis

As with the basic ideas underlying the location of economic activity, so too are there many levels at which we can approach the subject. A strategic narrowing of the analysis allows me to focus more sharply on the key messages. I focus on three levels of analysis, which may be delineated as description, theoretical explanation, and empirical explanation. In each of the three following chapters, the emphasis is on a different level of analysis, as well as a different area of application. The choice of area and level of analysis are complementary, and reflect the issue at hand. Nevertheless, each chapter contains elements of all three levels of analysis - the difference across chapters is mainly one of which level is most strongly emphasised.

Chapter 2 focusses on the size distribution of cities and includes both description and empirical estimation motivated by theory. Here, the crucial idea is Zipf's Law: the idea that city sizes follow a Pareto distribution with shape parameter equal to one. From this is derived the main estimated equation. In this chapter, the question is: do city size distributions follow Zipf's Law? In the last decade or so, as detailed in Chapter 2, many new theories have emerged purporting to explain the "empirical fact" that city size distributions follow a Pareto distribution. But what of this "empirical fact" which they claim to explain? The last detailed cross-country study on this issue was Rosen and Resnick (1980), which was performed on data from 1970, which found only equivocal evidence in favour of this hypothesis. While city systems do not as a rule experience massive changes overnight, it is conceivable that in the 30 years since the data used by Rosen and Resnick, new patterns may have emerged that justify a new study describing the size distribution of cities. Further, instead of simply replicating Rosen and Resnick's approach, advances in econometric methods and more careful analysis of the results may yield further insights not captured by Rosen and Resnick's classic paper. Such a study would enhance our understanding of city size distributions and better inform future theoretical work. These are the main motivations for the analysis in Chapter 2.

The key result of Chapter 2 is that Zipf's Law is statistically rejected far more often than we would expect based on random chance, calling into question the "empirical fact" underlying much of the recent theoretical literature. Using OLS as the estimation method, Zipf's Law is rejected for 53 of the 73 countries in my sample, while using the alternative Hill (1975) estimator for extreme values, Zipf's Law is rejected for 30 countries. There is also some evidence that city size distributions do not precisely follow a Pareto distribution. Closer inspection of the results suggests that European countries tend to have a more equal distribution of city sizes than Asian, African or Latin American countries. Extending the analysis, I find that this difference across continents is largely explained by differences in political history and stability, as well as differences in industrial structure and transportation infrastructure.

Theory-consistent empirical explanation is the key analytical device in Chapter 3. This chapter is a detailed study of the industrial structure in India in the period 1980 to 1997. It starts out with a brief description of the unequal distribution of industrial activity across Indian states, where some states are considerably more industrialised than others. It then goes on to ask whether a standard model of factor endowments and technology can explain this unequal distribution. Here, the basic framework is based on that popularised by Harrigan (1997) for his study of the industrial structure of OECD countries. The framework is that of the neoclassical trade model, from which an estimating equation is derived linking the share of an industry in a state to factor endowments and technology. The data used is a state-industry-year panel covering 16 major states for the period noted above, for 18 2-digit industries. In addition to simply applying the framework to data on India, I also extend the framework in two ways. First, I include additional variables as robustness checks, and second, in view of the economic liberalisation initiated by the Indian government in 1985 and 1991, I consider the implications of these natural experiments for the relationship between factor endowments and industrial structure.

The main finding of Chapter 3 is that factor endowments and technology are strongly associated with industrial structure in India. This finding is robust to the inclusion of additional controls for government policy and political history, and to market access. While technological superiority is associated with a larger share of that industry, there is only mixed evidence of continuous technological progress across all industries. Further, there is evidence of structural breaks in the relationship between factor endowments, technology and industrial structure in both 1985 and 1991, coinciding with the liberalisation of the Indian economy in these two years; the shift from a primarily state-controlled economy to a market-orientated one has changed the relationship between technology, factor endowments and industrial structure. These findings show that a neoclassical economic model can explain features of the economies of less developed countries, and that one need not always recourse to special models when analysing these countries.

Finally, Chapter 4 switches the main analytical approach to that of theoretical explanation, together with empirical explanation and testing of theoretical predictions. In this chapter, the question is: how can initial conditions in the form of absolute factor endowments impact on economic policy and what are the implications for industrial structure? While the role of initial conditions has been emphasised especially in the literature on economic geography, the channel of influence through public policy has only been recently developed, especially in the work of Baldwin et al (2003). Here, differently from Baldwin et al (2003) whose starting point is a model of economic geography, I develop a theoretical model of political economy that predicts a relationship between absolute factor endowments and government policy. The underlying model is one of electoral competition and special interest politics, based on the framework of Grossman and Helpman (1996). There are two main contributions of the theoretical analysis. First, I extend the framework to allow for multiple industries in order to consider the implications of political economy for industrial structure. Second, I extend the framework further to introduce factor mobility across locations, which introduces interesting interactions between initial factor endowments, government policies, and industrial structure.

The two main theoretical predictions are the following. First, the larger is the absolute capital stock in a country, the more favourable to capital will be the policies adopted by that country. Second, in a two country world, the country which starts out with more capital stock, will implement more favourable policies toward capital, and hence will be able to attract capital flows from the other country. An intial absolute advantage in capital stock may then be associated with a long run comparative advantage in the capital-intensive good.

I take the two predictions of the model to empirical data across Indian states between 1959 and 1997. I run two regressions: First, I regress a measure of labour regulation on absolute capital stocks, to test the first prediction above, and find that states with more capital stock do indeed have more favourable labour regulations toward capital. Since labour regulation may also influence the capital stock in a state, I run the regression using both OLS and Instrumental Variables (IV) methods to address the problem of reverse causality. In the IV case, I instrument capital stock using electricity generating capacity and bank credit, and I show that these instruments have highly significant effects on capital stock, and pass the standard tests for overidentification. The second regression which I run is a regression of the difference in industrial structure across Indian states on differences in labour regulation, and once again the empirical finding is consistent with the theoretical prediction: the greater is the difference between states in their labour regulation, the greater will be the difference between them in their industrial structure.

Chapter 2
Zipf's Law for Cities: A Cross Country Investigation[2]

2.1 Introduction

One of the most striking regularities in the location of economic activity is how much of it is concentrated in cities. Since cities come in different sizes, one enduring line of research has been in describing the size distribution of cities within an urban system.

The idea that the size distribution of cities in a country can be approximated by a Pareto distribution has fascinated social scientists ever since Auerbach (1913) first proposed it. Over the years, Auerbach's basic proposition has been refined by many others, most notably Zipf (1949), hence the term "Zipf's Law" is frequently used to refer to the idea that city sizes follow a Pareto distribution. Zipf's Law states that not only does the size distribution of cities follow a Pareto distribution, but that the distribution has a shape parameter (henceforth the Pareto exponent) equal to 1[3].

The issue addressed by this chapter is the extent to which Zipf's Law holds across a broad cross-section of countries. This is important for at least two main reasons. First, the most recent cross-country study of Zipf's Law was Rosen and Resnick (1980), which uses data from 1970. If we are interested in discovering the size distribution of cities today, we need to perform the analysis with a new, updated dataset. Such an analysis can take advantage not only of newer data, but also new econometric methods. Second, new empirical evidence would help drive theoretical work in this area. Several recent papers[4] have sought to provide theoretical explanations for the "empirical fact" that Zipf's Law holds in general across countries. It is therefore crucial to discover whether or not Zipf's

[2] This chapter is based on a paper accepted for publication in *Regional Science and Urban Economics*.

[3] Although to be clear, it is not a "Law", but simply a proposition on the size distribution of cities.

[4] A partial list includes Krugman (1996), Gabaix (1999), Axtell and Florida (2000), Reed (2001), Cordoba (2004), Rossi-Hansberg and Wright (2003), Eeckhout (2004). In addition, Brakman, Garretsen, Van Marrewijk and van den Berg (1999) and Duranton (2004, 2005) seek to model the empirical city size distribution, even if it doesn't follow Zipf's Law.

Law actually does hold - whether it does or not, it is the actual size distribution of cities which should be the objective of theoretical modelling.

The present chapter sets out to do four things: the first is to test Zipf's Law, using a new dataset. This dataset includes 73 countries, and is for the latest available census period (almost always after 1990). The second is to perform the analysis using the Hill estimator suggested by Gabaix and Ioannides (2004), who show that the OLS estimator is downward biased when estimating the Zipf regression, and that the Hill estimator is the maximum likelihood estimator if the size distribution of cities follows a Pareto distribution. Third, it non-parametrically analyses the distribution of the Pareto exponent to give an indication of its shape and to yield additional insights. Finally, this chapter sets out to explore the relationship between variation in the Pareto exponent, and some variables motivated by economic theory.

Our main findings are as follows. First, when we use OLS, for cities, Zipf's Law fails for the majority of countries. The size distribution often does not follow a Pareto distribution, and even when it does, the Pareto exponent is frequently statistically different from 1, with over half the countries exhibiting values of the Pareto exponent significantly greater than 1. This is consistent with Rosen and Resnick's earlier result. Second, we find that, for agglomerations, the Pareto exponent tends to be significantly less than 1 using OLS; this finding differs from Rosen and Resnick, who find that, for agglomerations, the Pareto exponent is equal to 1. We argue that this is largely due to a different sample of countries used in the analysis. The third main finding is that the OLS estimates of the Pareto exponent are unimodally distributed, while the Hill estimates are bimodal; this may indicate that at least one of the estimators is not appropriate. Fourth, we show that both political and economic geography variables are significant determinants of the size distribution of cities, although political variables tend to be more jointly significant than economic geography variables.

The next section outlines Zipf's Law and briefly reviews the empirical literature in the area. Section 2.3 describes the data and the methods, and section 2.4 presents the results, along with non-parametric analysis of the Pareto exponent. Section 2.5 takes the analysis further by seeking to uncover the relationship between these measures of the urban system and some economic variables, based on models of the size distribution of cities. The last section concludes.

2.2 Zipf's Law and Related Literature

The form of the size distribution of cities as first suggested by Auerbach in 1913 takes the following Pareto distribution:

$$y = Ax^{-a} \tag{2.1}$$

or

$$\log y = \log A - a \log x \tag{2.2}$$

where x is a particular population size, y is the number of cities with populations greater than x, and A and a are constants ($A, a > 0$). Zipf's (1949) contribution was to propose that the distribution of city sizes could not only be described as a Pareto distribution but that it took a special form of that distribution with $a = 1$ (with the corollary that A is the size of the largest city). This is Zipf's Law.

Gabaix and Ioannides (2004) and Cheshire (1999) are excellent surveys of this literature. The key empirical article in this field is Rosen and Resnick (1980). Their study investigates the value of the Pareto exponent for a sample of 44 countries, in 1970. Their estimates ranged from 0.81 (Morocco) to 1.96 (Australia), with a sample mean of 1.14. The exponent in 32 out of 44 countries exceeded unity. This indicates that populations in most countries are more evenly distributed than would be predicted by Zipf's Law. Rosen and Resnick also find that, where data was available, the value of the Pareto exponent is lower for urban agglomerations as compared to cities.

More detailed studies of Zipf's Law (e.g. Guerin-Pace's (1995) study of the urban system of France between 1831 and 1990 for cities with more than 2000 inhabitants) show that estimates of a are sensitive to the sample selection criteria. This implies that the Pareto distribution is not precisely appropriate as a description of the city size distribution. This issue was also raised by Rosen and Resnick, who explored adding quadratic and cubic terms to the basic form, giving

$$\log y = (\log A)' + a' \log x + b' (\log x)^2 \tag{2.3}$$

$$\log y = (\log A)'' + a'' \log x + b'' (\log x)^2 + c'' (\log x)^3 \tag{2.4}$$

They found indications of both concavity ($a' < 0$) and convexity ($a' > 0$) with respect to the pure Pareto distribution, with more than two thirds (30 of 44) of countries exhibiting convexity. As Guerin-Pace (1995) demonstrates, this result is also sensitive to sample selection[5].

Nitsch (2003) is an important recent contribution to this literature. In this paper, he provides a meta-analysis of Zipf's Law; that is, he looks at the results of 515 regressions from 29 previous studies, and performs a statistical analysis on these results. His paper therefore summarises the results of a century of empirical research on this topic. He finds that the average value of the Pareto exponent from all these studies is 1.09, and that the coefficient is larger for cities than for urban agglomerations (1.11 for cities versus 1.02 for urban agglomerations).

There have also been papers which seek to test directly some of the theoretical models of Zipf's Law; in particular, the idea, associated with Gabaix (1999) and Cordoba (2004), that Zipf's Law follows from Gibrat's Law. Black and Henderson (2003), for example, test whether the growth rate of cities in the US follows Gibrat's Law. They conclude that neither Zipf's Law nor Gibrat's Law apply in their sample of cities. On the other hand, Ioannides and Overman (2003), using similar data but a different method, find that Gibrat's Law holds in the US. This is an interesting development; however data limitations prevent us from being able to test for Gibrat's Law, as our dataset lacks sufficient time periods to track the growth path of cities over time (Ioannides and Overman use US data with ten time periods; in our dataset, the maximum number of time periods is four).

While obtaining the value for the Pareto exponent for different countries is interesting in itself, there is also great interest in investigating the factors that may influence the value of the exponent, for such a relationship may point to more interesting economic and policy-related issues. Rosen and Resnick (1980), for example, find that the Pareto exponent is positively related to per capita GNP, total population and railroad density, but negatively related to land area. Mills and Becker (1986), in their study of the urban system in India, find that the Pareto exponent is positively related to total population and the

[5] The addition of such terms can be viewed as a weak form of the Ramsey (1969) RESET test for functional form misspecification. In our sample, we find that the full RESET test rejects the null of no omitted variables almost every time.

percentage of workers in manufacturing. Alperovich's (1993) cross-country study using values of the Pareto exponent from Rosen and Resnick (1980) finds that it is positively related to per capita GNP, population density, and land area, and negatively related to the government share of GDP, and the share of manufacturing value added in GDP.

2.3 Data and Methods

2.3.1 Data

This chapter uses a new data set, obtained from the following website: Thomas Brinkhoff (2004): City Population, http://www.citypopulation.de. This site has data on city populations for over 100 countries. However, we have only made use of data on 75 countries, because for smaller countries the number of cities was very small (less than 20 in most cases). For each country, data is available for one to four census periods, the earliest record being 1972 and the latest 2001. This gives a total number of country-year pairs of observations of 197. For every country (except Peru and New Zealand), data is available for administratively defined cities. But for a subset of 26 countries (including Peru and New Zealand), there is also data for urban agglomerations, defined as a central city and neighbouring communities linked to it by continuous built-up areas or many commuters.

The precise definition of cities is an issue that often arises in the literature. Official statistics, even if reliable, are still based on the statistical authorities' definition of city boundaries. These definitions may or may not coincide with the economically meaningful definition of "city" (see Rosen and Resnick (1980) or Cheshire (1999)). Data for agglomerations might more closely approximate a functional definition, as they typically include surrounding suburbs where the workers of a city reside.

To alleviate fears as to the reliability of online data, we have cross-checked the data with official statistics published by the various countries' statistical agencies, the UN Demographic Yearbook and the Encyclopaedia Britannica Book of the Year (2001). The data in every case matched with one or more of these sources[6].

[6] For example, the figures for South Africa, Canada, Colombia, Ecuador, Mexico, India, Malaysia, Pak-

The lower population threshold for a city to be included in the sample, is obtained from the definition given by Brinkhoff (2004), who in turn obtains his definition from the national statistical agencies. This seems a reasonable way to proceed, as what is defined as a city in a small country, may not satisfy the definition of a city in a larger country. As a result, this lower threshold for inclusion varies from one country to another. On average, larger countries have higher thresholds, but also a larger number of cities in the sample. The countries chosen all have minimum thresholds of at least 10,000. Our sample of 75 countries includes all the countries in the Rosen and Resnick sample, except for Ghana, Sri Lanka and Zaire.

Some discussion of the sample selection criteria used here is in order. Cheshire (1999) raises this issue. He argues that there are three possible criteria: a fixed number of cities, a fixed size threshold, or a size above which the sample accounts for some given proportion of a country's population. He objects to the third criterion as it is influenced by the degree of urbanisation in the country. However, it is simple to see that the other two criteria he prefers are also problematic: the first because for small countries a city of rank n might be a mere village indistinguishable from the surrounding countryside, whereas for a large country the nth city might be a large metropolis. While the limitation of the second criterion is that when countries are of different sizes, a fixed threshold would imply that a different fraction of the urban system is represented in the sample. We therefore use a different threshold for each country; this threshold is determined mainly by data considerations, however as noted above, there exists a positive relationship between the size of a country and the threshold for inclusion. This seems in our opinion to represent the best way of describing the reality that large countries do have more cities than small countries on average, however, what is defined as a city in a small country might not be considered as such in a larger country.

As a check on the sensitivity of our results to different sample selection criteria, we performed two experiments. First, for all countries for which at least 50 cities are

istan, Saudi Arabia, South Korea, Vietnam, Austria and Greece are the same as those from the United Nations Demographic Yearbook. The figures for Algeria, Egypt, Morocco, Kenya, Argentina, Brazil, Peru, Venezuela, Indonesia, Iran, Japan, Kuwait, Azerbaijan, Philippines, Russia, Turkey, Jordan, Bulgaria, Denmark, Finland, Germany, Hungary, the Netherlands, Norway, Poland, Portugal, Romania, Sweden, Switzerland, Spain, Ukraine and Yugoslavia are the same as those from the Encyclopaedia Britannica Book of the Year. It should be noted that the Encyclopaedia Britannica Book of the Year 2001 lists Brinkhoff's website as one of its data sources, thus adding credibility to the data obtained from this website.

available, we restrict the sample in each country to the 50 largest cities, and run the Zipf regression for these 50 cities. Second, we restrict the sample of cities to all cities with a population of over 100000, thus maintaining a constant lower threshold across countries; these correspond to Cheshire's first two selection criteria above. In light of the discussion of Guerin-Pace (1995) above, it is unsurprising that the estimated value of the Pareto exponent changes as the sample size is changed, as there is some evidence of nonlinearity in the log-rank log-population plot in many countries.

Nevertheless, the overall picture is not very different when we use different selection criteria. In unreported results, we find that, first, for the 50 countries for which we have at least 50 cities, the mean value of the Pareto exponent is 1.20 when only 50 cities are included, against 1.16 when all available cities are included. This difference is not statistically significant (p-value of 0.13). Second, for the sample which fixes the lower threshold for inclusion, when all countries are included, the mean value of the Pareto exponent is 1.07, compared to 1.11 when the full sample is used. This difference is again not statistically significant (p-value of 0.17). Since the number of cities with more than 100000 people is very small in some countries, removing those countries with less than 10 cities using this criterion, leaves us with 49 countries, for which the mean value of the Pareto exponent is 1.14, compared to the full sample estimate for these 49 countries of 1.09; the p-value for the test of similarity of the two samples' means is 0.15.

As an additional test, data was kindly provided by Paul Cheshire on carefully defined Functional Urban Regions (FURs), for twelve countries in the EC and the EFTA. This dataset, by more carefully defining the urban system, might be viewed as a more valid test of Zipf's Law. However, because the minimum threshold in the dataset is 300,000, meaningful regressions were run for only the seven largest countries in the sample (France, West Germany, Belgium, the Netherlands, Italy, Spain, and the United Kingdom). This serves as an additional check on the validity of the results obtained using the main dataset. The results using Cheshire's dataset are similar to those obtained using Brinkhoff's dataset and are not reported for brevity.

Data for the second stage regression which seeks to uncover the factors which influence the Pareto exponent a is obtained from the World Bank World Development Indicators CD-ROM, the International Road Federation World Road Statistics, the UNIDO

Industrial Statistics Database, and the Gallup, Sachs and Mellinger (1999) geographical dataset. The GASTIL index (named after Raymond Gastil, who developed the methodology used in computing the index) is from Freedom House.

2.3.2 Methods

Two estimation methods are used in this chapter: OLS and the Hill (1975) method. Using OLS, two regressions are run:

$$\log y = \log A - a \log x \tag{2.2}$$

$$\log y = (\log A)' + a' \log x + b' (\log x)^2 \tag{2.3}$$

Equation (2.2) seeks to test whether $a = 1$ and A =size of largest city, while equation (2.3) seeks to uncover any non-linearities that could indicate deviations from the Pareto distribution. Both these regressions are run for each country and each time period separately, using OLS with heteroskedasticity-robust standard errors. This is done for all countries although a Cook-Weisberg test for heteroskedasticity has mixed results.

Measurement error in city populations may induce a correlation between the rank of a city and its population. As an additional check, the regressions were also run using Instrumental Variables (IV). We instrument current city population with city population from the previous observed period; since our data are from each country's population census, the lag can be between 5 and 15 years. When we have data for at least three time periods, both previous observations are used as instruments for present city population. The instruments have highly significant effects on the instrumented variable in the first stage regression, and when two instruments are used, IV passes the Sargan test for overidentification[7]. Results using IV are very similar to the OLS results, and are not reported.

One potentially serious problem with the Zipf regression is that it is biased in small samples. Gabaix and Ioannides (2004) show using Monte Carlo simulations that the coefficient of the OLS regression of equation (2.2) is biased downward for sample

[7] Using lagged values as instruments is appropriate only if shocks to city populations are not correlated across time. Otherwise the instruments would be correlated with the errors. If shocks are persistent, the Sargan test has low power, since it assumes that at least one of the instruments satisfies the exclusion restrictions.

sizes in the range that is usually considered for city size distributions. The reason for this is that, although the rank-size rule predicts that the second largest city will be half the size of the largest city, the 95 percent confidence interval for the ratio of the sizes of the two largest cities is $[1, 20]$. Therefore, the largest city will appear "too large", and in compensation, the OLS line will be less steep, so that the OLS estimate of a will be less than the true value.

Further, because the ranking procedure creates a positive correlation between the residuals, the OLS standard errors are incorrect. Davidson and MacKinnon (1993) argue that with positive correlation in the residuals, OLS underestimates the true standard error, and this is confirmed by Gabaix and Ioannides (2004). They show that OLS standard errors are grossly underestimated (by a factor of at least 5 for typical sample sizes), thus leading to too many rejections of Zipf's Law. They also show that, even if the actual data exhibit no nonlinear behaviour, OLS regression of equation (2.3) will yield a statistically significant coefficient for the quadratic term an incredible 78% of the time in a sample of 50 observations. This is again caused by the correlation in the residuals, which causes OLS to underestimate the true standard error.

To take into account these concerns, we use the Hill (1975) estimator as an alternative procedure for calculating the value of the Pareto exponent, as suggested by Gabaix and Ioannides (2004) in their survey of the literature. Under the null hypothesis of the power law, it is the maximum likelihood estimator. Thus, for a sample of n cities with sizes $x_1 \geq ... \geq x_n$, this estimator is:

$$\widehat{a} = \frac{n-1}{\sum_{i=1}^{n-1} (\ln x_i - \ln x_n)} \tag{2.5}$$

while the standard error is given by:

$$\sigma_n (\widehat{a}) = \widehat{a}^2 \left(\frac{\sum_{i=1}^{n-1} (\ln x_i - \ln x_{i+1})^2}{n-1} - \frac{1}{\widehat{a}^2} \right)^{\frac{1}{2}} n^{-\frac{1}{2}} \tag{2.6}$$

The best known paper that has used the Hill estimator for estimating Zipf's Law is Dobkins and Ioannides (2000), who find that the Pareto exponent is declining in the US over time, using either OLS or the Hill method. However, they also find that the Hill estimate of the Pareto exponent is always smaller than the OLS estimate. Since the OLS estimate is meant to be downward biased, this is puzzling. Additional evidence from Black and Henderson (2003), who use a very similar dataset, suggests the interpretation that the reliability of the Hill estimate is dependent on the curvature of the log rank – log population plot, something which we return to in subsection 2.4.3 below.

There are two issues in comparing the two alternative estimators, both of which revolve around the fact that the Hill estimator is a maximum likelihood (ML) estimator. First, as a ML estimator, the Hill estimator makes stronger assumptions about the size distribution of cities (i.e. that it follows a Pareto distribution), and hence may be sensitive to violations of these assumptions. On the other hand, OLS is not the best linear unbiased estimator under the null hypothesis of the Pareto distribution, as the OLS assumptions of independently and normally distributed errors are violated. However, OLS *may* perform better than the Hill estimator if the null hypothesis does not hold.

The second issue is that, as a ML estimator, the desirable properties of the Hill estimator, such as consistency and efficiency, hold only asymptotically. Given the relatively small sample sizes for many of the countries in our sample, it is difficult to claim that these asymptotic properties hold. For example, Gabaix and Ioannides (2004) show that the Hill estimator is biased in small samples.

We plot the kernel density functions for the estimates of the Pareto exponent using the OLS and Hill estimators to give a better description and further insights of the distribution of the values of the exponent across countries. From these plots, we find that the Hill estimates exhibit a bias when the size distribution of cities does not follow a Pareto distribution. The Pareto exponent is then used as the dependent variable in a second stage regression where the objective is to explain variations in this measure using variables obtained from models of political economy and economic geography.

2.4 Results

In this section, we discuss only the results for the latest available year for each country, for the regressions (2.2) and (2.3) for Zipf's Law and the Hill estimator (2.5). This is to reduce the size of the tables. In the text, brief comparisons will be made to results from earlier periods where relevant. Full details are available from the author upon request.

2.4.1 Zipf's Law for Cities

Tables 2.1 and 2.2 present the detailed results of the OLS regressions of (2.2) and (2.3) and the Hill estimator (2.5) for cities. Note that because the Hill estimator is based on the assumption that the size distribution of cities follows a Pareto distribution, it is only possible to calculate the value of the Pareto exponent (but not the quadratic term) using the Hill method.

For OLS, the largest value of the Pareto exponent (1.719) is obtained for Kuwait, followed by Belgium, whereas the lowest value is obtained for Guatemala at 0.7287, followed by Syria and Saudi Arabia. Unsurprisingly, the former two countries are associated with a large number of small cities and no primate city, whereas in the latter three countries one or two large cities dominate the urban system. The left side of Table 2.3 summarises the statistical significance of the Pareto exponent, using both OLS and the Hill estimator for cities. Using OLS, a is significantly greater than 1 for 39 of our 73 countries, while a further 14 observations are significantly less than one. This is consistent with Rosen and Resnick's result, as they find that 32 of their 44 countries had a Pareto exponent significantly greater than 1, while 4 countries had the exponent significantly less than 1.

For the Hill estimator, the country with the largest value of the Pareto exponent is Belgium with a value of 1.742, followed by Switzerland and Portugal. The lowest values were obtained for South Korea, Saudi Arabia and Belarus. It is clear that the identity of the countries with the highest and lowest values for the Pareto exponent differ between the OLS and the Hill estimators. In fact, the correlation between the OLS estimator and the Hill estimator is not exceptionally high, at 0.7064 for the latest available period (the Spearman rank correlation is 0.6823). This can be interpreted as saying that, because we use a different number of cities for each country, and since the OLS bias is larger for small samples, we should not expect the results of the OLS and Hill estimators to be perfectly correlated. Indeed we find a weak negative correlation between the difference in estimates using the two methods, and the number of cities in the sample (corr=-0.2575, significant at the 5 percent level using the latest available period).

			OLS				Hill
Country	Year	Cities	a	a'	b'	Log A	a
Algeria	1998	62	1.351**	-2.338	0.041	18.80**	1.359*
Egypt	1996	127	0.996	-2.912**	0.078**	15.06	1.094
Ethiopia	1994	63	1.065	-4.313**	0.143**	14.23	1.334*
Kenya	1989	27	0.817**	-1.949**	0.049**	11.30**	1.006
Morocco	1994	59	0.874**	-1.019	0.006	13.07**	0.930
Mozambique	1997	33	0.859**	1.015**	-0.081**	12.13**	0.811
Nigeria	1991	139	1.041**	-0.949	-0.004	15.98**	1.046
South Africa	1991	94	1.359**	-1.103	0.011	19.12**	1.268*
Sudan	1993	26	0.909	-0.214	-0.028	13.07*	1.007
Tanzania	1988	32	1.010	-1.817	0.035	13.69	0.909
Australia	1998	131	1.228**	7.894**	-0.406**	17.60**	0.801**
Argentina	1999	111	1.044	2.994**	-0.165**	16.13**	0.967
Brazil	2000	411	1.134**	-0.096**	-0.042**	18.37**	1.061
Canada	1996	93	1.245**	0.427	-0.069	18.09**	1.253
Chile	1999	67	0.867**	-0.652	-0.009	13.02**	0.791*
Colombia	1999	111	0.902**	-0.804	-0.004	14.03**	0.935
Cuba	1991	55	1.090	-3.686**	0.109**	15.13	1.318
Dominican Republic	1993	23	0.847	-2.638*	0.075*	11.69**	0.803
Ecuador	1995	42	0.808**	-1.409	0.026	11.69**	0.902
Guatemala	1994	13	0.729**	-3.658**	0.125**	9.71**	1.207
Mexico	2000	162	0.973	1.951**	-0.117*	15.83	0.813**
Paraguay	1992	19	1.014	-1.958	0.042	13.15	1.257
USA	2000	667	1.378**	-1.951**	0.024**	21.38**	0.934
Venezuela	2000	91	1.063*	-0.725	-0.014	15.82**	1.428**
Azerbaijan	1997	39	1.035	-5.213**	0.181**	13.66	1.361
Bangladesh	1991	79	1.091	-4.188**	0.127**	15.63	1.355*
China	1990	349	1.181**	1.434**	-0.101**	19.57**	0.962
India	1991	309	1.188**	-0.745	-0.017**	19.39**	1.218**
Indonesia	1990	235	1.135**	-2.633**	0.061**	17.42**	1.233**
Iran	1996	119	1.058**	-1.554	0.020	16.25**	1.053
Israel	1997	55	1.089*	1.498**	-0.115**	14.89**	1.041
Japan	1995	221	1.317**	-0.633	-0.027	20.65**	1.225**
Jordan	1994	34	0.898**	-2.483**	0.069**	12.08**	1.063
Kazakhstan	1999	33	0.962	4.862**	-0.244**	13.88	0.865
Kuwait	1995	28	1.719**	5.898**	-0.355**	20.55**	1.686*
Malaysia	1991	52	0.872*	2.819**	-0.162**	12.66**	0.842
Nepal	2000	46	1.187**	-2.096	0.041	15.58**	1.259
Pakistan	1998	136	0.962	-2.484**	0.061**	15.04**	1.063

Notes: Under the OLS estimator, a is the value of the Pareto exponent from the linear regression equation (2.2), while Log A is the intercept term. a' and b' are the coefficients on the linear and quadratic terms, respectively, of the quadratic regression (2.3). Under the Hill estimator, a is the value of the Pareto exponent calculated using equation (2.5). Cities: Number of cities.
* significant at 5%; ** significant at 1%; for a, significantly different from 1; for a', significantly different from (-1), for b', significantly different from 0; for log A, significantly different from the log of the population of the largest city. a is defined as a positive value; to compare the coefficients of $\log x$ in equation (2) and $(\log x)'$ in equation (3), we compare (-a) with a'.

Table 2.1: Results of OLS regression of equations (2.2) and (2.3) and the Hill estimator (2.5), for cities, for latest year of each country.

			OLS				Hill
Country	Year	Cities	a	a'	b'	Log A	a
Philippines	2000	87	1.080	3.439**	-0.184**	16.50**	0.863
Saudi Arabia	1992	48	0.782**	0.024**	-0.033*	11.91**	0.730**
South Korea	1995	71	0.907**	-0.318	-0.023	14.58**	0.685**
Syria	1994	10	0.744*	-1.471	0.028	10.90**	1.086
Taiwan	1998	62	1.059**	0.148**	-0.049**	15.75**	0.929
Thailand	2000	97	1.186**	-4.944**	0.155**	16.68	1.418**
Turkey	1997	126	1.054	-2.666**	0.064**	16.17	1.185
Uzbekistan	1997	17	1.049	-8.954**	0.305**	14.79	1.511*
Vietnam	1989	54	0.976**	-1.420	0.018**	14.13*	0.803
Austria	1998	70	0.988	-3.986**	0.136**	13.08	1.423**
Belarus	1998	41	0.844**	0.649**	-0.064**	12.24**	0.750*
Belgium	2000	68	1.589**	-2.186	0.026	20.50**	1.835*
Bulgaria	1997	23	1.114	-4.842**	0.153**	15.14	1.286
Croatia	2001	24	0.921	-1.769	0.038	12.09**	0.955
Czech Republic	2001	64	1.168**	-3.519**	0.103**	15.70**	1.267
Denmark	1999	58	1.361**	-2.760**	0.0627*	17.56**	1.375*
Finland	1999	49	1.192**	-2.468**	0.057**	15.64**	1.346
France	1999	104	1.451**	-4.189**	0.114**	20.25**	1.639**
Germany	1998	190	1.238**	-0.302**	-0.038**	18.65**	1.255**
Greece	1991	43	1.413**	-6.202**	0.204**	18.60**	1.480*
Hungary	1999	60	1.124**	-4.019**	0.125**	15.16	1.279
Italy	1999	228	1.381**	-3.907**	0.106**	19.81**	1.497**
Netherlands	1999	97	1.473**	-0.433	-0.045	20.03**	1.444**
Norway	1999	41	1.270**	-4.595**	0.148**	16.26**	1.403
Poland	1998	180	1.183**	0.393**	-0.068**	17.29**	1.091
Portugal	2001	70	1.382**	-4.136**	0.124**	17.79**	1.670**
Romania	1997	70	1.109*	-0.056	-0.045	15.94**	1.060
Russia	1999	165	1.186**	1.246*	-0.094*	18.94**	1.034
Slovakia	1998	42	1.303**	-4.486**	0.143**	16.56**	1.481*
Spain	1998	157	1.186**	-0.066	-0.047	17.57**	1.097
Sweden	1998	120	1.439**	-1.218	-0.010	19.18**	1.287**
Switzerland	1998	117	1.437**	-6.126**	0.223**	17.85**	1.739**
Ukraine	1998	103	1.025	1.579	-0.106**	15.76**	1.020
Yugoslavia	1999	60	1.183*	-2.282	0.048	15.88**	1.167
United Kingdom	1991	232	1.401**	-3.550**	0.089**	20.31**	1.398**

Notes: Under the OLS estimator, a is the value of the Pareto exponent from the linear regression equation (2.2), while Log A is the intercept term. a' and b' are the coefficients on the linear and quadratic terms, respectively, of the quadratic regression (2.3). Under the Hill estimator, a is the value of the Pareto exponent calculated using equation (2.5). Cities: Number of cities.
* significant at 5%; ** significant at 1%; for a, significantly different from 1; for a', significantly different from (-1), for b', significantly different from 0; for log A, significantly different from the log of the population of the largest city. a is defined as a positive value; to compare the coefficients of $\log x$ in equation (2) and $(\log x)'$ in equation (3), we compare (-a) with a'.

Table 2.2: (continued from Table 2.1) Results of OLS regression of equations (2.2) and (2.3) and the Hill estimator (2.5), for cities, for latest year of each country.

For statistical significance of the Hill estimator, one key result of Gabaix and Ioannides (2004) is that the standard errors of the OLS estimator are grossly underestimated. Thus, Table 2.3 shows that using the Hill estimator, 43 of the 73 countries (or 59 percent) in our sample for cities have values of the Pareto exponent that are not significantly different from the Zipf's Law prediction of 1, with 24 countries having values significantly higher than 1, while only 6 countries have values significantly less than 1. Hence the overall pattern of statistical significance of the Pareto exponent for the Hill estimator follows that of the OLS estimator, except that there are fewer significant values for the Hill estimator because the (correct) standard errors are larger than those estimated using OLS.

The top half of Table 2.4 summarises the results of both OLS and Hill estimators for cities. The first set of observations labelled Full Sample shows the summary statistics for a for the latest available observation in all countries. We see that the mean of the Pareto exponent for cities using OLS is approximately 1.11. This lends support to Rosen and Resnick's result (they obtain a mean value for the Pareto exponent of 1.13). For the Hill estimator, the mean of the Pareto exponent is 1.167, which is statistically different from the mean for the OLS estimator at the 5% level. This is consistent with the argument in Gabaix and Ioannides (2004), that OLS is biased downward in small samples. However, we also find that for 34 of the 73 countries, the Hill estimate of the Pareto exponent is smaller than the OLS estimate, which may indicate a bias in the Hill estimator (recall that the Hill estimator is supposed to overcome the downward bias of the OLS estimator; subsection 2.4.3 discusses this further). Such a bias may arise from a violation of the key assumption underlying the Hill estimator, that city sizes follow a Pareto distribution.

Breaking down the results by continents, we find that, for both OLS and Hill estimators, there seems to be a clear distinction between Europe, which has a high average value of the Pareto exponent (the average being above 1.2 using OLS) and Asia, Africa, and South America, which have low average values of the exponent (below 1.1 using OLS)[8]. This indicates that populations in Europe are more evenly spread over the system of cities than in the latter three continents. Indeed, 21 of the 26 European countries

[8] A two-sample t-test shows that the average Pareto exponent for Europe is significantly different from that for the rest of the world as a whole.

Cities					Agglomerations			
Summary results: OLS estimates of a								
Continent	a < 1	a = 1	a > 1		Continent	a < 1	a = 1	a > 1
Africa	3	4	3		Africa	1	1	
N America		1	2		N America	2	1	
S America	4	4	2		S America	3	2	
Asia	5	8	10		Asia	3	2	
Europe	2	3	21		Europe	5	2	2
Oceania			1		Oceania	2		
Total	14	20	39		Total	16	8	2
Summary results: OLS estimates of b'								
Continent	b' < 0	b' = 0	b' > 0		Continent	b' < 0	b' = 0	b' > 0
Africa	1	6	3		Africa	1		1
N America		1	2		N America	2	1	
S America	3	4	3		S America		5	
Asia	11	5	8		Asia	2	2	1
Europe	4	7	14		Europe	3	4	2
Oceania	1				Oceania	1	1	
Total	20	23	30		Total	9	13	4
Summary results: OLS estimates of A (compared to largest city)								
Continent	Less than	Equal to	Greater than		Continent	Less than	Equal to	Greater than
Africa	3	4	3		Africa	1	1	
N America		1	2		N America	1	2	
S America	5	2	3		S America	5		
Asia	6	7	10		Asia	2	3	
Europe	2	3	21		Europe	5	3	1
Oceania			1		Oceania	2		
Total	16	17	40		Total	16	9	1
Summary results: Hill estimator for a								
Continent	a < 1	a = 1	a > 1		Continent	a < 1	a = 1	a > 1
Africa		7	3		Africa	1	1	
N America	1	1	1		N America	1	2	
S America	1	9			S America	1	4	
Asia	2	14	7		Asia		5	
Europe	1	12	13		Europe	1	8	
Oceania	1				Oceania	1	1	
Total	6	43	24		Total	5	21	

Table 2.3: Breaking down the results of OLS regressions (2.2) and (2.3) and the Hill estimator (2.5): Statistical significance (5 percent level) in the latest available observation, for cities and urban agglomerations.

OLS for cities	Obs	Mean	Std. Dev.	Min	Max
Full sample	73	1.1114	0.2042	0.7287	1.719
Africa	10	1.028	0.191	0.8169	1.3595
North America	3	1.2008	0.1705	1.0127	1.3451
South America	10	0.9531	0.1363	0.7287	1.1391
Asia	23	1.0633	0.2027	0.7442	1.719
Europe	26	1.2306	0.1735	0.8435	1.54
Oceania	1	1.2685		1.2685	1.2685
Hill for cities	Obs	Mean	Std. Dev.	Min	Max
Full sample	73	1.1667	0.2583	0.685	1.7422
Africa	10	1.0762	0.1868	0.8107	1.3586
North America	3	1.1772	0.2724	0.8751	1.4039
South America	10	1.0255	0.1819	0.8028	1.3177
Asia	23	1.1226	0.2602	0.685	1.6859
Europe	26	1.3063	0.2542	0.7503	1.7422
Oceania	1	0.8398		0.8398	0.8398
OLS for agglomerations	Obs	Mean	Std. Dev.	Min	Max
Full sample	26	0.8703	0.1526	0.5856	1.2301
Africa	2	0.8661	0.3374	0.6275	1.1047
North America	3	0.8941	0.0648	0.8345	0.9631
South America	5	0.851	0.1065	0.7025	0.9904
Asia	5	0.8778	0.1316	0.6813	1.0001
Europe	9	0.9111	0.1725	0.6349	1.2301
Oceania	2	0.6844	0.1399	0.5856	0.7833
Hill for agglomerations	Obs	Mean	Std. Dev.	Min	Max
Full sample	26	0.8782	0.2276	0.5058	1.5897
Africa	2	1.0477	0.7665	0.5058	1.5897
North America	3	0.7202	0.1714	0.5225	0.8273
South America	5	0.8812	0.2084	0.5229	1.0567
Asia	5	0.8837	0.1133	0.7286	1.0384
Europe	9	0.9402	0.1178	0.6778	1.0903
Oceania	2	0.6458	0.1939	0.5087	0.7829

Table 2.4: Summary statistics: by continent: Values of a using OLS and Hill estimators, for cities and agglomerations.

in our sample had a significantly greater than 1 using OLS. These findings raise the interesting question of why these differences exist between different continents. Could it be the different levels of development, or institutional factors? Section 2.5 will seek to identify the reasons for these apparently systematic variations.

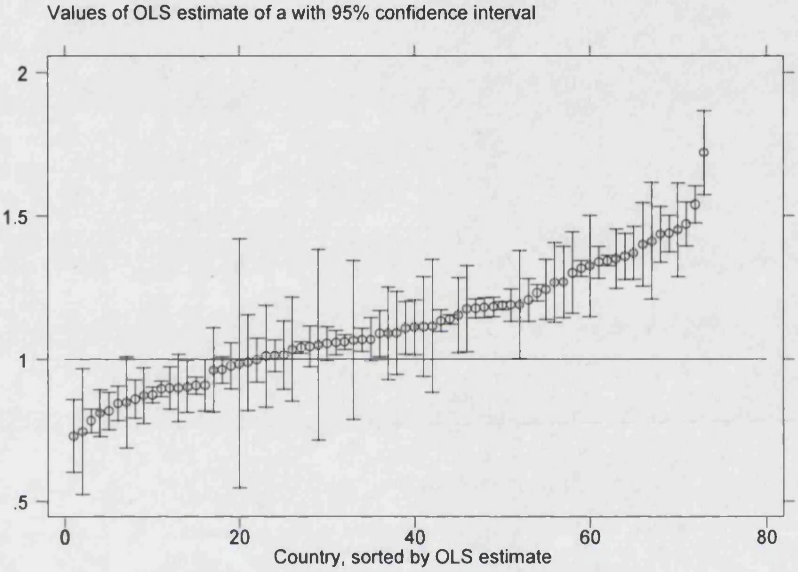
We can also compare the results of the latest period with those of earlier periods. For 69 countries, there is data for at least two periods. In this earlier period, the mean of the Pareto exponent using OLS across all countries is 1.086, and this is significantly different from 1 at the 5 percent level for 49 countries. Out of these 49 countries, 33 of them have a value of the Pareto exponent significantly greater than 1. Europe once again has the largest average value of the Pareto exponent, 1.227, which is again significantly different from the average for all other countries (this average is 1.001) at the 5 percent level. For the Hill estimator, the mean across all countries is 1.146 (again, significantly different from 1 at the 5 percent level). The null hypothesis that the Pareto exponent is equal to 1, is rejected for 25 of the 69 countries in this earlier sample. Of these, 20 countries have a value of the Pareto exponent significantly greater than 1. As before, the Hill estimates for this earlier period follow the same patterns as with the latest period, with Europe exhibiting a much higher value than the other continents.

For a subsample of 44 countries, data is available for at least three periods. The OLS-obtained mean of the Pareto exponent for this sample of earlier observations is 1.124, and this is significantly greater than 1 for 23 countries, and significantly less than 1 for 5 countries. The comparative results are broadly similar to those of the later periods. This suggests that the size distribution of cities exhibits persistence, in that the results do not change very much over time. One clear message that comes through is that we reject the null hypothesis that the Pareto exponent is equal to 1, much more often than we would expect based on random chance, irrespective of the estimation method or time period used.

Tables 2.1 and 2.2 also provide the results of the value of the intercept term of the linear regression (2.2). As Alperovich (1984, 1988) notes, a proper test of Zipf's Law should not only consider the value of the Pareto exponent, but also whether the intercept term A is equal to the size of the largest city. We find, perhaps unsurprisingly, that whenever the Pareto exponent is significantly greater than 1, the intercept term is also greater than the size of the largest city (this is almost by construction: in a log-rank – log-population plot, the largest city enters on the horizontal axis, so that, provided the largest city is not too far from the best-fit line, if the line has slope equal to 1, it must be that the vertical intercept is equal to the horizontal intercept). A comparison of the first and third panels of Table 2.3 confirms this result, as the estimates of the Pareto exponent and the intercept follow almost identical patterns.

For values of the quadratic term, the patterns are less strong. Recalling that a significant value for the quadratic term represents a deviation from the Pareto distribution, we find the following results. For the cities sample, 30 observations or 41% display a value for the quadratic term significantly greater than zero, indicating convexity of

Figure 2.1: Values of the OLS estimate of the Pareto exponent with the 95% confidence interval, for the full sample of 73 countries for the latest available period, sorted according to the Pareto exponent.

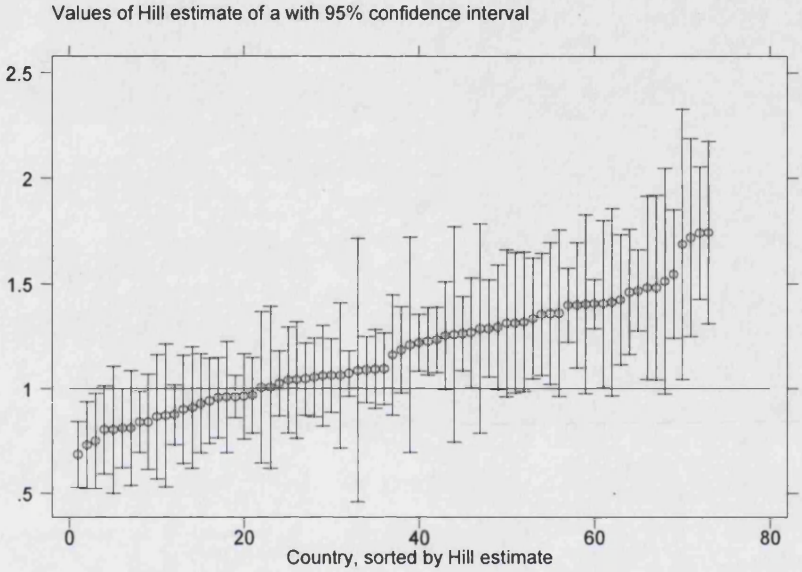


the log-rank – log-population plot, while 20 observations (26%) have a value for the quadratic term significantly less than zero, indicating concavity of the log-rank – log-population plot. These results are again in the same direction as those obtained by Rosen and Resnick (1980), but less strong (they find that the quadratic term is significantly greater than zero for 30 out of 44 countries).

One additional result that arises out of the quadratic regression (2.3) is that including the quadratic term often dramatically changes the value or even the sign of the coefficient of the linear term. This is actually a fairly common result in the literature; Rosen and Resnick (1980) find that, in the quadratic regression (2.3), the linear term is positive for six of their 44 countries; this compares with 17 of our 73 countries (in Tables 2.1 and 2.2, a is a positive value, but the coefficient on the term $(\log x)$ in the linear specification (2.2) is $(-a)$). This sign change in the linear term can be explained by the different interpretations of the linear term in equations (2.2) and (2.3). In a linear regression, the linear term gives the slope of the best-fit line. But in a quadratic regression, the linear term gives the location of the maximum or minimum point of the best-fit line[9].

[9] If the function is $y = a + bx + cx^2$, then y is maximised when $x = -\left(\frac{b}{2c}\right)$ and c is negative. Then

Figure 2.2: Values of the Hill estimate of the Pareto exponent with the 95% confidence interval, for the full sample of 73 countries for the latest available period, sorted according to the Pareto exponent.



For the baseline linear model, Figures 2.1 and 2.2 graph the estimates for the Pareto exponent for all countries using the latest available observation, using the OLS and Hill estimators respectively, including the 95% confidence interval and sorting the sample according to values of the Pareto exponent (the confidence intervals do not form a smooth series since each country has a different standard error). The figures show graphically what the tables summarise. We find that the confidence intervals for the Hill estimator are larger than for the OLS estimator, and hence that we reject the null hypothesis that the Pareto exponent is equal to 1 more frequently using the OLS estimator (in the figures, a rejection occurs when no portion of the vertical line indicating the confidence interval intersects the horizontal line at 1.00).

b may be positive if the maximum of y occurs at positive values of x. This is possible in our dataset since, while in the dataset x and y must by construction be negatively related, observed values of x (the log of city size) lie between 9 and 17, so that there may be an (out of sample) maximum of y at positive values of x.

2.4.2 Zipf's Law for Urban Agglomerations

It is frequently claimed (see e.g. Rosen and Resnick (1980) or Cheshire (1999)) that Zipf's Law holds if we define cities more carefully, by using data on urban agglomerations rather than cities. To see if this is in fact the case, we also run the OLS regressions (2.2) and (2.3), and the Hill estimator, for our sample of 26 countries for which data on urban agglomerations is available.

The results for the latest available period for urban agglomerations are presented in Table 2.5, and are summarised in the lower half of Table 2.4. Using either OLS or the Hill estimator, the mean value of the Pareto exponent is lower for agglomerations than for cities (the value is 0.870 for OLS and 0.8782 for the Hill estimator). This is to be expected, since the Pareto exponent is a measure of how evenly distributed is the population (the higher the value of the exponent, the more even in size are the cities). Large cities tend to have a larger fraction of their populations in suburbs, which are part of the urban agglomeration but not the core city, and so urban agglomerations may be expected to be more uneven in size than core cities. Once again a slight pattern can be observed across continents; the small sample size however does not make this result particularly strong.

The right side of Table 2.3 summarises the statistical significance of both OLS and the Hill estimator for agglomerations. Using OLS, the Pareto exponent for agglomerations is significantly greater than one for only two countries (the Netherlands and the United Kingdom), while fully 16 of the 26 observations for agglomerations were significantly less than one (a similar result albeit with weaker significance is obtained using the Hill estimator). Results for the intercept term of the linear regression (2.2) track the results for the Pareto exponent very closely. For the quadratic regression (2.3), we find that half of the observations (13 out of 26) have a value for the quadratic term not significantly different from zero, with 9 or 35% having a quadratic term significantly less than zero.

This result is broadly confirmed using data from earlier time periods. For a subsample of 18 countries, we have data for at least two time periods. In the earlier period, the average value of the Pareto exponent using OLS is 0.8312, whereas using the Hill es-

			OLS				Hill
Country	Year	Agg	a	a'	b'	Log A	a
Morocco	1982	10	1.105	-14.207**	0.485**	15.85	1.590
South Africa	1991	23	0.628**	3.819**	-0.175**	10.16**	0.506**
Australia	1998	21	0.586**	0.911	-0.058*	9.44**	0.509**
New Zealand	1999	26	0.783**	-0.809	0.001	10.86**	0.783
Argentina	1991	19	0.703**	-1.118	0.015	11.13**	0.523**
Brazil	2000	18	0.990	-1.125	0.004	16.56	0.974
Canada	1996	56	0.835**	-0.264	-0.023	13.10**	0.827
Colombia	1993	16	0.828**	-0.238	-0.021	12.94**	1.057
Ecuador	1990	43	0.905	-2.017	0.047	12.76**	0.957
Mexico	2000	38	0.963	-1.386	0.015	15.67	0.811
Peru	1993	65	0.829**	-1.584	0.032	12.35**	0.896
USA	2000	336	0.885**	3.499**	-0.167**	16.10	0.523**
Bangladesh	1991	43	0.807**	-2.932**	0.084**	12.16**	0.914
India	1991	178	0.958**	0.156**	-0.042**	16.29	0.900
Indonesia	1990	193	1.000	-1.132	0.005	15.84	1.038
Jordan	1994	10	0.681**	0.238	-0.037	9.71**	0.729
Malaysia	1991	71	0.943	3.336**	-0.187**	13.79	0.837
Austria	1998	34	0.750**	-0.634	-0.005	10.66**	0.678**
Denmark	1999	27	0.817**	-3.722**	0.124**	11.22**	1.090
France	1999	114	1.023	-1.526	0.020	15.79	1.064
Germany	1996	144	0.890**	0.570**	-0.058**	14.64**	0.889
Greece	1991	15	0.635**	-3.987**	0.132**	9.22**	0.950
Netherlands	1999	21	1.230*	0.830	-0.080	17.54**	0.970
Norway	1999	19	0.883*	-1.772	0.039	11.77**	0.921
Switzerland	1998	48	0.985	-0.167	-0.036**	13.72	0.956
United Kingdom	1991	151	1.030*	-0.919	-0.005	16.05	0.944

Notes: Under the OLS estimator, a is the value of the Pareto exponent from the linear regression equation (2.2), while Log A is the intercept term. a' and b' are the coefficients on the linear and quadratic terms, respectively, of the quadratic regression (2.3). Under the Hill estimator, a is the value of the Pareto exponent calculated using equation (2.5). Agg: Number of urban agglomerations.
* significant at 5%; ** significant at 1%; for a, significantly different from 1; for a', significantly different from (-1), for b', significantly different from 0; for log A, significantly different from the log of the population of the largest city. a is defined as a positive value; to compare the coefficients of $\log x$ in equation (2) and $(\log x)'$ in equation (3), we compare (-a) with a'.

Table 2.5: Results of OLS regression of equations (2.2) and (2.3), and the Hill estimator (2.5), for urban agglomerations, for latest year of each country

timator it is 0.8381. Using OLS, the null hypothesis that the Pareto exponent is equal to 1, is rejected for 11 countries (all significantly less than 1), while using the Hill estimator, the null is rejected for 5 countries, again all significantly less than 1.

Therefore, the claim that Zipf's Law holds for urban agglomerations (see Rosen and Resnick (1980), Cheshire (1999)), is strongly rejected for our sample of countries in favour of the alternative that agglomerations are more uneven in size than would be predicted by Zipf's Law. Our result differs from that of Rosen and Resnick, primarily because the sample of countries is different. Using the same sample as Rosen and Resnick[10] (less Italy for which data is unavailable), we get an average value for the Pareto exponent of 0.9639 using OLS, and 0.8543 using the Hill estimator[11]. This compares with an average of 1.002 for Rosen and Resnick when Italy is excluded. This highlights the danger of drawing conclusions from too small a sample; our larger sample is more representative of the population of countries than Rosen and Resnick's more limited sample.

2.4.3 Non-parametric analysis of the distribution of the Pareto exponent

An additional way of describing the distribution of the Pareto exponent across countries is to construct the kernel density functions. The advantage of doing so is that it gives us a more complete description of how the values of the Pareto exponent are distributed – whether it is unimodal or bimodal, or whether it is normally distributed or not. In implementing this method, we use the latest available observation for each country. We construct the efficient Epanechnikov kernel function for the Pareto exponent for both the OLS and Hill estimators, using the "optimal" window width (the width that minimises the mean integrated square error if the data were Gaussian and a Gaussian kernel were used), and including an overlay of the normal distribution for comparative purposes.

Figure 2.3 shows the kernel function for the OLS estimator. It is slightly right skewed relative to the normal distribution, but is clearly unimodal (with the mode ap-

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[10] Their sample is Brazil, France, India, Italy, Mexico and the US.

[11] This is yet another instance in which the Hill estimate is less than the OLS estimate, which goes against our priors. The large discrepancy between the two averages is largely driven by the US, but for Brazil, Mexico and India, the Hill estimate is also less than the OLS estimate.

Figure 2.3: Kernel density function for Pareto exponent using the OLS estimator (optimal window width=0.076).

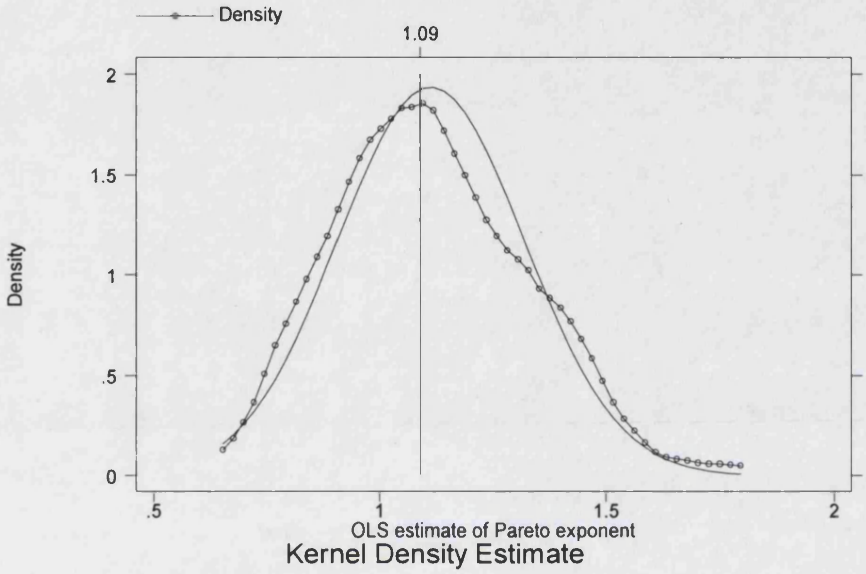


Figure 2.4: Kernel density function for the Pareto exponent using the Hill estimator (optimal window width=0.098).

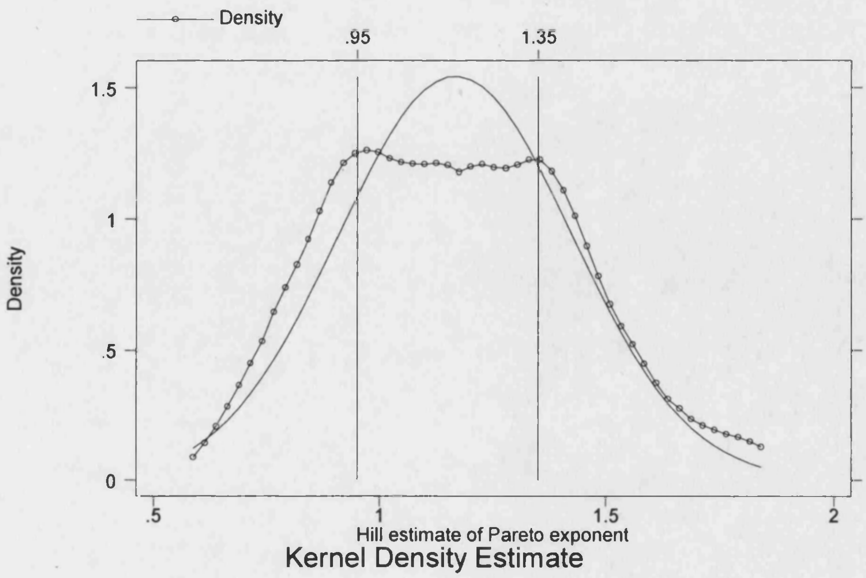
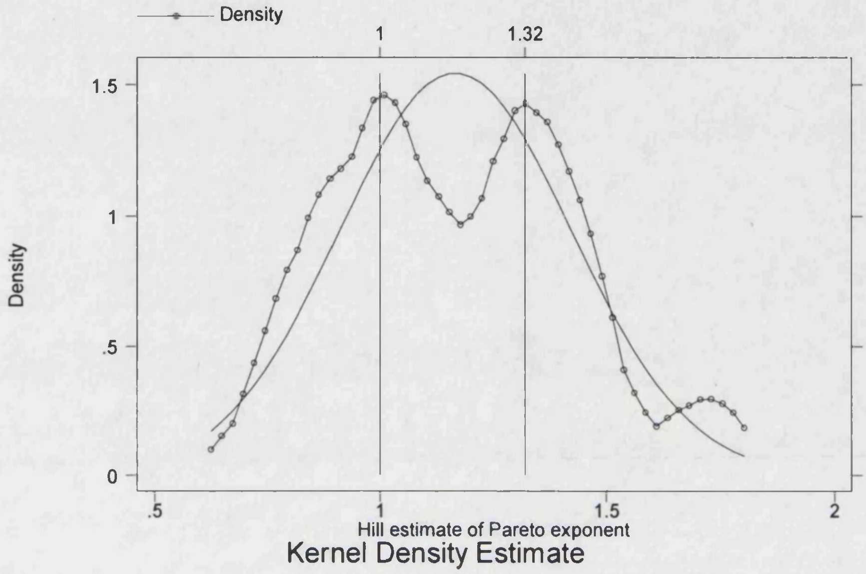


Figure 2.5: Kernel density function for the Pareto exponent using the Hill estimator (window width=0.006, vertical lines at x=1.00 and x=1.32).

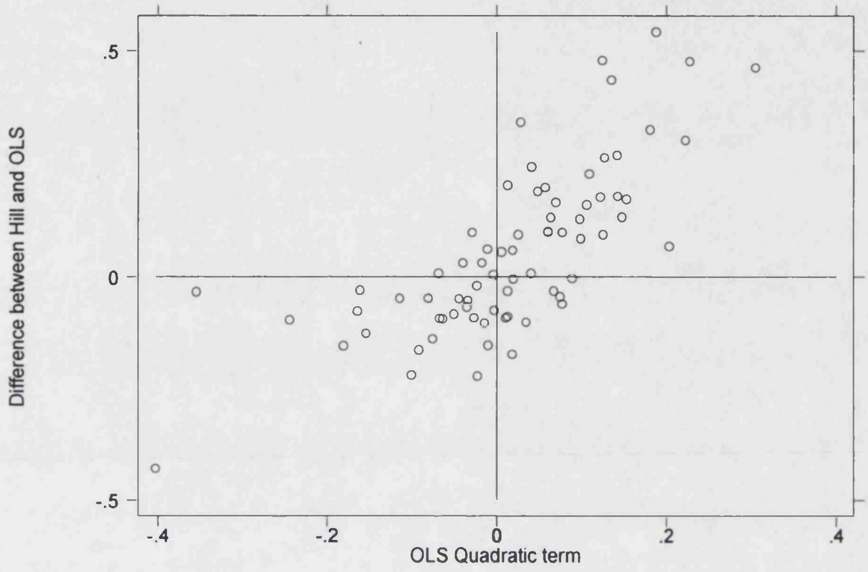


proximately equal to 1.09) and its distribution is quite close to the normal distribution. Figure 2.4 shows the kernel function for the Hill estimator. What is interesting (and a priori unexpected) is that the distribution is not unimodal. Instead, we find that there is no clearly defined mode, rather that observations are spread roughly evenly across ranges of the Pareto exponent between 0.95 and 1.35. Experimenting with narrower window widths (Figure 2.5, where the window width is 0.06)[12] shows that the distribution is in fact bimodal, with the two modes at approximately 1.0 and 1.32.

Closer inspection of the relationship between the OLS estimator and Hill estimator of the Pareto exponent, and the value of the coefficient for the quadratic term in the OLS regression equation (2.3), reveals further insights as to what is actually happening. We find that, while the correlation between the OLS estimator of the Pareto exponent and the quadratic term is very low (corr=-0.0329 for the latest available period), the correlation between the Hill estimator and the quadratic term is high (corr=0.5063). Further, the correlation between the difference between the Hill estimator and the OLS estimator,

[12] While the "optimal" window width exists, in practice choosing window widths is a subjective exercise. Silverman (1986) shows that the "optimal" window width oversmooths the density function when the data are highly skewed or multimodal.

Figure 2.6: Relationship between difference between Hill and OLS estimators, and the value of the quadratic term in equation (2.3).



and the quadratic term, is even higher (corr=0.7476) (see figure 2.6). What we find is that, in general, the Hill estimator is larger than the OLS estimator if the quadratic term is positive (i.e. the log rank – log population plot is convex), while the reverse is true if the quadratic term is negative. In other words, when the size distribution of cities does not follow a Pareto distribution, the Hill estimator may be biased. This interpretation is also consistent with the difference between the Hill and OLS estimates of the Pareto exponent for US cities in Dobkins and Ioannides (2000), and the concavity of the US log rank - log population plot in Black and Henderson (2003) (see the brief discussion in subsection 2.3.2 above). Therefore, we should tread carefully in drawing conclusions from the results of the Hill estimator.

2.5 Explaining Variation in the Pareto Exponent

2.5.1 Theory and methods

The Pareto exponent a can be viewed as a measure of inequality: the larger the value of the Pareto exponent, the more even is the population of cities in the urban system (in the limit, if $a = \infty$, all cities have the same size). There are many potential explanations for variations in its value. One possibility is a model of economic geography, as exemplified by Krugman (1991) and Fujita, Krugman and Venables (1999). These models can be viewed as models of unevenness in the distribution of economic activity. For certain parameter values, economic activity is agglomerated, while for other parameter values, economic activity is dispersed.

The key parameters of the model are: the degree of increasing returns to scale, transport costs and other barriers to trade within a country, the share of mobile or footloose industries in the economy. Equation (9.25) in Fujita, Krugman and Venables (1999) summarises the impact of these factors on the market potential function, which determines the stability of a monocentric (highly concentrated) economy:

$$\frac{d\Omega\left(0\right)}{dr} = \sigma\left[\left(1-\mu\right)\tau^{A} - \left(1+\rho\right)\mu\tau^{M}\right] \tag{2.7}$$

Here, $\Omega\left(0\right)$ is the market potential at a city, r is the location of a point, σ is the elasticity of substitution between varieties in manufacturing (which proxies for the degree of scale economies), μ is the share of expenditure in manufacturing, τ^{A} is the transport cost of agricultural goods, τ^{M} is manufacturing transport cost, and ρ is the intensity of preference for a variety of the manufacturing good. For a city to exist at location 0, the market potential function at location 0 must be negative. Fujita, Krugman and Venables (1999) show that the steeper is the market potential function at location 0, the less stable will be the monocentric equilibrium (i.e. the more likely that new cities will form). This would imply a more even distribution of economic activity, and hence a larger value of the Pareto exponent.

Therefore, a larger value of the Pareto exponent is related to a larger value of σ (the smaller are scale economies), and a larger value of μ (the larger the share of manufacturing in the economy). Transport costs in agriculture and manufacturing, τ^{A} and τ^{M}, have conflicting effects on the Pareto exponent. In addition, Chapter 18 of Fujita, Krugman and Venables (1999) shows that a greater extent of international trade weakens the force for agglomeration and leads to a more even distribution of economic activity[13].

But we can also think of political factors that could influence the size distribution of cities. One possibility is the model proposed by Ades and Glaeser (1995). They argue that political stability and the extent of dictatorship are key factors that influence the concentration of population in the capital city. Their model seeks to explain the size of the capital city, but may be reinterpreted in terms of the urban system as a whole. In this interpretation, political instability or a dictatorship should imply a more uneven distribution of city sizes (i.e. a smaller Pareto exponent). A dictatorship would be more likely to have a large capital city since rents are more easily obtainable in the national capital. However, regional capitals would also be a source of rents (albeit at a smaller scale than in the national capital). We should therefore see a hierarchy of cities where cities at each tier of the hierarchy are much larger in size than cities at a lower tier. Similarly, if the country is politically unstable, then if the government is unwilling or unable to protect the population outside large cities, we should find a more uneven distribution of city sizes since the population would flock to the larger cities.

However, it is possible that dictatorships may drive the population away from major centres of activity, if the people fear persecution by the authorities. Also, political instability may lead to migration away from the larger cities, if these cities become centres of instability. Theory does not give us a clear prediction as to the expected sign of the geographical and political variables. Therefore, we do not seek to accept or reject either of these theories, but instead attempt to discover which variables play a more significant role in explaining variations in the Pareto exponent.

We also control for other variables that could influence the size distribution of cities, including the size of the country as measured by population, land area or GDP, and also for possible effects of being located in different continents.

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[13] Strictly speaking, to the best of our knowledge, existing models of economic geography are not able to generate a size distribution of cities that follows a Pareto distribution, without making additional assumptions (c.f. Brakman et al (1999)). They are however able to generate cities of different sizes, and here we seek to explore whether the variables associated with models of economic geography, impact on the size distribution of cities, in the way that is predicted by the models.

Thus our estimated equation is:

$$a_{it} = \delta_0 + \delta_1 GEOG + \delta_2 POLITIC + \delta_3 CONTROL + \delta_4 DUMMIES + u_{it} \quad (2.8)$$

Where a_{it} is the Pareto exponent, $GEOG$ is the vector of economic geography variables: scale economies (the share of industrial output in high-scale industries as measured by Pratten (1988)), transport costs (the inverse of road density), non-agricultural economic activity as a share of total GDP, and trade as a share of GDP (a detailed definition of the variables is given in the Data Appendix to this chapter). $POLITIC$ is a group of political variables: the GASTIL index of political rights and civil liberties, total government expenditure as a share of GDP, an indicator variable for the time the country achieved independence, and an indicator variable for whether the country had an external war between 1960 and 1985. The GASTIL index is our measure of dictatorship, while the timing of independence and external war are our measures of political stability[14]. Government expenditure can be interpreted as an indicator capturing the extent of government involvement in the economy, through redistribution of tax revenues to reduce regional inequalities. $CONTROL$ is a set of variables controlling for the size of the country; here the control variables used are the log of per capita GDP in constant US dollars, the log of the land area of the country, and the log of population. Finally, $DUMMIES$ is the set of continent and period dummies; period dummy i is an indicator variable taking value equal to 1 if the observation is the ith observation for the country, zero otherwise.

For this second stage, we use the full sample, including multiple periods for each country if data is available. This gives an unbalanced panel with a total of 79 observations, drawn from 44 countries (data for some independent variables is unavailable for some countries). One potential problem with an unbalanced panel is that the panel may be endogenously unbalanced; this poses a potential sample selection problem. To address this possibility, we also run the regression using a balanced panel panel of countries. By using a balanced dataset, we have a total of 48 observations from 24 countries, distributed as 9 countries from Europe, 1 from North America, 4 from South America, 3 from Africa, and 7 from Asia.

[14] Following Ades and Glaeser (1995), we would have liked to use as the measure of political instability, the number of attempted coups, assassinations or revolutions from the Barro-Lee (1994) dataset. However the years of their data do not match ours.

One potential concern is the effect of using an estimated coefficient from a first stage regression as a dependent variable in a second stage regression. Lewis (2000) shows that the danger in doing so is that there could be measurement error in the first stage estimate, leading to inefficient estimates in the second stage. Heteroskedasticity might also arise if the sampling uncertainty in the (second stage) dependent variable is not constant across observations. He advocates the use of feasible GLS (FGLS) to overcome this problem. However, Baltagi (1995) points out that FGLS yields consistent estimates of the variances only if $T \to \infty$. This is clearly not the case for our sample; hence FGLS results are not reported. We instead report the results of OLS estimation with standard errors clustered by country. Clustering the standard errors by country allows for heteroskedasticity and non-independence of observations within each cluster, but observations are assumed to be independent across clusters[15].

2.5.2 Results

Table 2.6 presents the results for the unbalanced panel, using the OLS estimate of the Pareto exponent as the dependent variable (running the regression with the Hill estimate as the dependent variable yields almost identical results). Columns (1) to (3) present the results using all available observations. Column (1) is the model without size and continent controls. Of the economic geography variables, only the degree of scale economies is highly significant. For the political variables, government expenditure share and the war dummy are significant. The signs of the coefficients suggest that more high-scale industry, higher government expenditure shares, and experiencing an external war, are associated with larger values of the Pareto exponent, or a more equal distribution of city sizes. The economic geography variables are jointly significant at the 10 percent level, while the political variables are jointly significant at the 1 percent level; both geography and politics play significant roles in determining the distribution of city sizes.

Columns (2) and (3) augment the basic specification by including size and regional controls. Including these controls reduces the significance of the degree of scale economies as an explanatory variable for the value of the Pareto exponent. None of the

[15] An alternative way of calculating the standard errors using OLS estimation is to use the Beck and Katz (1995) panel-corrected standard errors, which makes the assumption that observations are heteroskedastic and contemporaneously correlated across panels.

	(1)	(2)	(3)	(4)	(5)	(6)
Dep variable	OLS	OLS	OLS	OLS	OLS	OLS
Transport cost	-0.6137	-0.2494	-0.4167	-0.835	-0.4592	-0.6519
	(1.63)	(0.53)	(0.98)	(1.87)*	(1.02)	(1.53)
International trade (% of	-0.0915	0.0315	-0.0229	-0.0477	0.0479	-0.0171
GDP)	(1.21)	(0.46)	(0.23)	(0.74)	(0.68)	(0.18)
Non-agricultural economic	-0.1925	-0.9524	-0.5346	-0.5545	-1.4064	-0.8332
activity (% of GDP)	(0.42)	(1.45)	(0.97)	(1.27)	(2.24)**	(1.44)
Scale economies	0.495	0.471	0.4251	0.5345	0.5112	0.4424
	(2.37)**	(1.83)*	(1.52)	(2.23)**	(1.85)*	(1.40)
GASTIL index of dictatorship	-0.0399	-0.016	-0.0382	-0.0324	-0.0024	-0.028
	(1.68)	(0.69)	(2.06)**	(1.32)	(0.10)	(1.29)
Total government expenditure	0.7512	0.7682	0.7482	0.9852	0.9127	0.9359
(% of GDP)	(2.85)***	(3.25)***	(1.73)*	(4.04)***	(4.16)***	(2.11)**
Timing of independence	-0.0576	-0.066	-0.1401	-0.0947	-0.0958	-0.1672
	(1.43)	(1.82)*	(2.98)***	(2.26)**	(2.56)**	(3.55)***
War dummy (external war,	0.2047	0.1217	0.1442	0.2231	0.114	0.1553
1960-1985)	(3.60)***	(1.84)*	(2.15)**	(4.60)***	(1.83)*	(2.45)**
Ln(land area)		0.0048	0.0286		0.0096	0.0252
		(0.17)	(0.80)		(0.39)	(0.80)
Ln(Population)		0.0549	0.011		0.0441	0.0029
		(2.16)**	(0.34)		(1.74)*	(0.10)
Ln(GDP per capita)		0.0953	0.0573		0.1115	0.0537
		(2.41)**	(1.55)		(2.69)**	(1.13)
Africa Dummy			0.1287			0.1046
			(1.09)			(0.82)
Asia Dummy			0.2049			0.1976
			(1.41)			(1.32)
North America Dummy			-0.0638			-0.0082
			(0.42)			(0.05)
South America Dummy			-0.1235			-0.1266
			(1.06)			(0.87)
Oceania Dummy			-0.0835			-0.033
			(0.54)			(0.22)
Period 1 dummy	0.0723	0.0813	0.0348	0.0304	0.0481	-0.0029
	(1.23)	(1.39)	(0.56)	(0.42)	(0.64)	(0.05)
Period 2 dummy	0.0923	0.108	0.0392	0.0587	0.0785	0.008
	(1.87)*	(1.91)*	(0.68)	(0.93)	(1.12)	(0.15)
Period 3 dummy	0.0103	0.0511	0.0059	-0.0093	0.004	-0.0277
	(0.16)	(0.62)	(0.08)	(0.12)	(0.04)	(0.39)
R-squared	0.49	0.59	0.66	0.55	0.64	0.70
F-test geography	2.44*	1.19	0.68	2.24*	1.81	0.89
F-test politics	5.62***	3.46**	3.95***	12.86***	6.36***	5.88***
Observations	79	79	79	72	72	72
Countries	44	44	44	40	40	40

Notes: t statistics in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%. Estimation method is OLS with standard errors clustered by country. The dependent variable is the OLS estimate of the Pareto exponent. The sample is an unbalanced panel. In columns (1) to (3), all available observations are used. In columns (4) to (6), all former Eastern European communist countries are excluded. Period dummy 1 is an indicator variable taking value 1 if the observation is the first observation for the country, and so on. Period 4 is the excluded period. Transport cost is the inverse of road density. Scale economies is the fraction of industrial output in high-scale industries as defined by Pratten (1988). The GASTIL index ranges from 1 to 7, with lower values indicating more freedom. The F-test of geography and politics are the F-statistics of the test of joint significance of all economic geography and political variables, respectively.
See the Data Appendix for details on the sources and construction of the variables.

Table 2.6: Panel estimation of equation (2.8): The determinants of the Pareto exponent, full sample.

other economic geography variables are close to statistical significance. For the political variables, while the inclusion of additional control variables reduces the significance of government expenditure shares and the war dummy, the GASTIL index and the timing of independence now become statistically significant. The signs associated with the coefficients indicate that larger values of the GASTIL index (less political freedom) and the more recently a country achieved independence, are associated with smaller values of the Pareto exponent (more uneven distribution of city populations). These results are consistent with the predictions of Ades and Glaeser (1995). When these controls are included, the geography variables are no longer jointly significant, but the political variables remain jointly significant at at least the 5 percent level. This shows that the political variables have more significant effects on the size distribution of cities than the economic geography variables which we use.

Columns (4) to (6) of Table 2.6 present results of the same regression, run for the sample excluding former communist countries, in the belief that in the rest of the world, free market forces play a more important role than political forces. Dropping the former communist countries improves the overall fit of the estimated equation, since R-squared increases. Apart from the GASTIL index which becomes statistically insignificant in all specifications, none of the other results are changed by dropping the former communist countries. The economic geography variables remain jointly insignificant in columns (5) and (6), while the political variables become even more jointly significant compared to columns (2) and (3).

Of the geographical control variables and the continent dummies, in the full specifications (3) and (6), they are mainly insignificant. In columns (2) and (5), when not controlling for continents, larger countries both in terms of population and per capita GDP, are positively related to the Pareto exponent, indicating that larger and wealthier countries have more even distributions of cities. This effect disappears when continent dummies are included. This indicates that the economic geography and the political variables account for most of the variation in the Pareto exponent across continents noted in Section 2.4.

The period dummies are mostly statistically insignificant (period 4 is the excluded period), apart from the dummy for the second observation being marginally significant in the full sample when continent dummies are not included; none of the results are changed if the period dummies are excluded from the regression. There is no evidence that the Pareto exponent differs across time periods in a way that is not captured by the other variables in the regression.

Table 2.7 presents the results of the same regression, using a balanced panel of observations. Columns (1) to (3) report the results for all available countries, while columns (4) to (6) replicate this exercise excluding former communist countries; in practice, this means dropping 4 observations from 2 countries: Bulgaria and Hungary. The results are quite similar those with the full, unbalanced panel; the coefficients for statistically significant variables have the same signs in both tables, but in general the t-statistics for the balanced panel are smaller, which reflects the smaller sample size and consequent imprecision of the estimates. In Table 2.7 as in Table 2.6, excluding the former communist countries improves the fit of the model in terms of R-squared as well as in terms of the statistical significance of the explanatory variables.

With the balanced panel, transport cost is the only economic geography variable which is robustly significant across all specifications. The sign of the coefficient suggests that lower transport costs are associated with larger values of the Pareto exponent; that is, a more even size distribution of cities. Scale economies and the share of international trade are significant in some specifications especially when former communist countries are excluded from the sample. Greater international trade or lower scale economies are associated with a more uneven distribution of city sizes.

Of the political variables, the GASTIL index is never significant in any specification, while government expenditure share is significant in most specifications; greater government involvement in the economy is associated with less inequality in city sizes. The timing of independence is statistically significant when former communist countries are excluded from the sample, with more recent independence being associated with a less even distribution of city sizes. Table 2.7 does not include the war dummy as none of the countries in the balanced panel experienced an external war between 1960 and 1985. Comparing F-tests of the joint significance of economic geography and political variables, again the political variables show more joint significance than the economic geography variables. However, now, when we exclude former communist countries from

	(1)	(2)	(3)	(4)	(5)	(6)
Dep variable	OLS	OLS	OLS	OLS	OLS	OLS
Transport cost	-1.1654	-1.1374	-1.116	-1.4724	-1.4718	-1.536
	(2.21)**	(2.20)**	(1.79)*	(6.89)***	(4.03)***	(3.39)***
International trade (% of	-0.1871	-0.0545	-0.0915	-0.1166	-0.0577	-0.1269
GDP)	(1.74)*	(0.58)	(0.61)	(3.22)***	(0.82)	(0.83)
Non-agricultural economic	0.0802	-0.6807	-0.7575	-0.4512	-0.8328	-0.9261
activity (% of GDP)	(0.13)	(0.76)	(0.78)	(1.05)	(1.03)	(1.49)
Scale economies	0.4492	0.457	0.3593	0.4658	0.4597	0.3136
	(1.47)	(1.20)	(0.88)	(2.60)***	(2.59)***	(0.76)
GASTIL index of dictatorship	-0.0186	0.0089	-0.0224	-0.0152	0.0032	-0.0221
	(0.50)	(0.26)	(0.56)	(1.36)	(0.35)	(0.86)
Total government expenditure	0.9509	0.9378	0.9007	1.1944	1.159	1.1583
(% of GDP)	(3.35)***	(3.38)***	(1.44)	(10.82)***	(5.53)***	(2.53)**
Timing of independence	-0.0311	-0.0428	-0.1248	-0.076	-0.0627	-0.1652
	(0.61)	(0.89)	(1.50)	(2.19)**	(2.02)**	(4.08)***
Ln(land area)		0.0309	0.0296		0.0332	0.0156
		(1.02)	(0.55)		(1.72)*	(0.42)
Ln(Population)		0.0207	-0.0082		0.0057	-0.0248
		(0.54)	(0.18)		(0.58)	(1.47)
Ln(GDP per capita)		0.0843	0.0785		0.0588	0.0377
		(1.72)*	(1.48)		(1.45)	(0.85)
Africa Dummy			0.1982			0.1785
			(1.14)			(1.98)**
Asia Dummy			0.2334			0.242
			(1.19)			(1.33)
North America Dummy			0.0359			0.1498
			(0.13)			(0.76)
South America Dummy			-0.0352			-0.0541
			(0.19)			(0.44)
Period 1 dummy	0.018	0.01	0.0233	0.0135	0.0057	0.0234
	(0.64)	(0.29)	(0.71)	(2.06)**	(0.46)	(2.07)**
R-squared	0.56	0.63	0.66	0.63	0.67	0.71
F-test geography	2.32*	1.65	1.32	2.57*	2.45*	2.34*
F-test politics	4.12**	4.41**	1.72	18.11***	9.27***	3.24**
Observations	48	48	48	44	44	44
Countries	24	24	24	22	22	22

Notes: t statistics in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%. Estimation method is OLS with standard errors clustered by country. The dependent variable is the OLS estimate of the Pareto exponent. The sample is a balanced panel with 2 observations for each country. In columns (1) to (3), the full sample is used. The countries in the full sample are: Austria, Bulgaria, Canada, Chile, Colombia, Ecuador, Egypt, Finland, France, Greece, Hungary, India, Italy, Jordan, Kuwait, Malaysia, Morocco, Netherlands, Philippines, South Africa, South Korea, Sweden, Turkey and Venezuela. In columns (4) to (6), the former Eastern European communist countries Bulgaria and Hungary are excluded. Period dummy 1 is an indicator variable taking value 1 if the observation is the first observation for the country; period 2 is the excluded period. Transport cost is the inverst of road density. Scale economies is the fraction of industrial output in high-scale industries as defined by Pratten (1988). The GASTIL index ranges from 1 to 7, with lower values indicating more freedom. The F-test of geography and politics are the F-statistics of the test of joint significance of all economic geography and political variables, respectively.
See the Data Appendix for details on the sources and construction of the variables.

Table 2.7: Panel estimation of equation (2.8): The determinants of the Pareto exponent, balanced panel.

the sample, the economic geography variables are jointly significant at the 10 percent level. Therefore, both economic geography and politics have statistically significant effects on the size distribution of cities.

In columns (1) to (3), none of the country size, regional and time controls are significant. When former communist countries are excluded, African countries are found to have more equal distributions of city sizes than European countries (the excluded category). There is also some evidence that countries had a more even distribution of city sizes in the first period of the sample.

Comparing our results to previous findings, we find that our results for columns (3) and (6) of Table 2.6 (including all the variables and controls) are broadly in line with those of Alperovich (1993). However, we get somewhat different results from those of Rosen and Resnick, as they find that the Pareto exponent is positively related to per capita GNP, total population and railroad density, and negatively related to land area. One likely explanation for this difference in results is that our specification is more complete than the one used by Rosen and Resnick. In their specification, Rosen and Resnick include variables such as GNP per capita, population, land area, and railway density. Using their specifications, we are able to replicate the sign (but not always the significance) which they obtain in two out of three specifications, and achieve higher R^2 than they do. Our preferred specifications in columns (3) and (6) include all of these variables (albeit without the nonlinear functional forms which they adopt), and include others which are motivated by theoretical considerations. The fact that our specification is more complete than that of Rosen and Resnick can also be seen from the larger R^2 that we obtain (0.66) compared to their largest R^2 of 0.23 (and a largest R^2 of 0.50 which we obtain by following Rosen and Resnick's specification).

2.6 Conclusion

This chapter set out to test Zipf's Law for cities, using a new dataset and two alternative methods – OLS and the Hill estimator. Using either method, we reject Zipf's Law much more often than we would expect based on random chance. Using OLS, we reject the Zipf's Law prediction that the Pareto exponent is equal to 1, for 53 of the 73 countries in our sample. This result is consistent with the classic study by Rosen and Resnick (1980), who reject Zipf's Law for 36 of the 44 countries in their sample. We get a slightly different result using the Hill estimator, where we reject Zipf's Law for a minority of countries (30 out of 73).

Therefore, the results we obtain depend on the estimation method used, and in turn, the preferred estimation method would depend on our sample size and on our theoretical priors – whether or not we believe that Zipf's Law holds. If we believe that city sizes follow a Pareto distribution, then the Hill estimator is appropriate. OLS is biased in small samples and the ranking of cities creates a positive correlation between the residuals. The Hill estimator addresses these concerns, but if city sizes do not follow a Pareto distribution, then the Hill estimator may give biased results.

The average value of the Pareto exponent for urban agglomerations is less than 1 (and significantly so for over half the sample using OLS); Zipf's Law fails for urban agglomerations. This is a new result, as previous work (e.g. Rosen and Resnick (1980)) have tended to find that the Pareto exponent is equal to 1 if data on urban agglomerations are used. This is likely due to a sample selection effect, as we have a larger and more representative sample of countries than do Rosen and Resnick.

In attempting to explain the observed variations in the value of the Pareto exponent, we sought to relate the value of the Pareto exponent to several variables used in models of the size distribution of cities. We find that both economic geography and political variables have statistically significant effects on the size distribution of cities, although political variables tend to be more jointly significant than economic geography variables.

Finally, our empirical results point to two implications for theoretical work seeking to explain Zipf's Law and the size distribution of cities more generally. First, theoretical models should address the fact that there are fairly large variations in the observed city size distribution. Zipf's Law holds some of the time, but theories should be able to explain deviations from Zipf's Law as well. Second, whilst existing models based on stochastic processes have been able to replicate Zipf's Law, it is desirable to develop models which embed these processes in a more satisfactory micro-founded framework. In this light, recent work by Rossi-Hansberg and Wright (2003), Eeckhout (2004) and Duranton (2004, 2005) point the way forward in this literature.

2.A Data Appendix to Chapter 2

This appendix describes the variables used in the regressions (the full list of data sources is given in the text). Unless otherwise mentioned, all data are from the World Bank World Development Indicators CD-ROM.

Scale economies is the degree of scale economies, constructed as the share of industrial output in high-scale industries where the definition of high-scale industries is obtained from Pratten (1988). The method used is to obtain the output of 3-digit industries from the UNIDO 2001 Industrial Statistics Database, then use Table 5.3 in Pratten (1988) to identify the industries that have the highest degree of scale economies, and divide the output of these industries by total output of all manufacturing industries[16].

Transport cost is transport cost, measured using the inverse of road density (total road mileage divided by land area). Source: United Nations WDI CD-ROM and International Road Federation World Road Statistics.

Non-agricultural economic activity is the share of non-agricultural value-added in GDP

GASTIL index is a combination of measures for political rights and civil liberties, and ranges from 1 to 7, with a lower score indicating more freedom. Source: Freedom House.

Total government expenditure is total government expenditure as a share of GDP.

War dummy is a dummy indicating whether the country had an external war between 1960 and 1985. Source: Gallup, Sachs and Mellinger (1999).

Timing of independence is a categorical variable taking the value 0 if the country achieved independence before 1914, 1 if between 1914 and 1945, 2 if between 1946 and 1989, and 3 if after 1989. Source: Gallup, Sachs and Mellinger (1999).

[16] Strictly speaking, this approach to calculating the degree of scale economies is valid only if technologies are similar across countries; it may be possible, for example, that some industries are high-scale in some countries, but low-scale in other countries.

Trade (% of GDP) is the ratio of total international trade in goods and services to total GDP.

Ln(GDP per capita) is the log of per capita GDP, measured in constant US dollars.

Ln(land area) is the log of land area, measured in square kilometres.

Ln(population) is the log of population.

Chapter 3
Factor Endowments and The Location of Industry in India

3.1 Introduction

The factor endowments model is one of the key theories in the international economist's toolkit. This is despite the fact that many empirical studies have found that the model does not seem to hold empirically (see, for example, Leontief (1953), Bowen, Leamer and Sveikauskas (1987), Trefler (1993, 1995)). However, it is clear that many of the strict assumptions associated with the basic factor-endowments model - identical technologies and preferences across countries, identical qualities of inputs and outputs, no trade barriers or transport costs - do not hold in the real world. Consequently, estimates of the model that allow for differences in the above characteristics have been able to fit the data more closely than strict versions of the model (e.g. Trefler (1993, 1995), Harrigan (1995, 1997), Harrigan and Zakrajsek (2000), Davis and Weinstein (2001), Redding and Vera-Martin (2004)).[17]

The main motivation of this chapter is to estimate the relationship between factor endowments, technology, and the location of production using state-level data on industries in India. Provided that the assumptions of the model hold, this relationship should hold both across and within countries. In this regard, there are clear benefits of using within-country rather than cross-country data, since within-country data are more likely to be comparable, any measurement error biases may be expected to work in a similar direction, and more generally the assumptions of the basic model listed above are more likely to hold across states within a country than across different countries. Also, it relates to the original work of Ohlin, who notes in the preface to *The Theory of Trade*: "... international trade is only a special case of what could be called interlocal trade, that is,

[17] For some excellent recent surveys of the empirical literature on factor endowments and trade-related issues, see e.g. Helpman (1999), Davis and Weinstein (2002), or Harrigan (2003).

exchange between locations which are characterised by incomplete mobility of factors and commodities between them." (Ohlin (1924)).

There are several reasons why India makes an interesting case study for the relationship between technology, factor endowments, and the location of production. First, as we document in section 3.2 below, there is great heterogeneity across Indian states in terms of factor endowments and industrial structure. Second, our data covers a period of rapid change in both economic performance and government policy. India was essentially a centrally planned economy prior to 1985, when Rajiv Gandhi started liberalising the economy. These initial steps was followed by a much more comprehensive liberalisation starting in 1991. Finally, India is a developing country, which contrasts with previous studies which have mainly concentrated on developed countries (e.g. Davis, Weinstein, Bradford and Shimpo (1997) and Bernstein and Weinstein (2002) who look at the case of Japan).

The literature on the liberalisation of the Indian economy is immense and no attempt is made here to list all possible sources. Some recent surveys of the progress and performance of the liberalisation programmes include Basu and Pattanaik (1997), Bajpai and Sachs (1999), Krueger and Chinoy (2002), Ahluwalia (2002), Bajpai (2002), Srinivasan (2003) and Panagariya (2004). The general consensus seems to be that, while the reform process has increased the real growth rate of the Indian economy (from an average of 3.5 percent between 1950 and 1980, to 5.7 percent in the 1980s, to an average of 6.2 percent in the 1990s), it is still unfinished, and much more needs to be done especially with regard to some sectors such as infrastructure, labour laws, health and education which have so far not been the main focus of the reforms. Section 3.2 gives a more detailed description of the reform process especially as it relates to industrial activity.

The contributions of the present chapter are as follows. First, we use a new panel of cross-state industry data on India between 1980 and 1997 to estimate the relationship between factor endowments, technological differences, and the location of production. Second, we investigate the significance and impact of the policy reforms of 1985 and 1991 on the relationship between factor endowments, technologies and industrial structure. Finally, we perform some robustness checks on the basic framework, by including additional variables as controls, to try to capture the many other factors that are likely to be influential in determining the location of industrial production in India.

To briefly preview our results: First, our estimate of Total Factor Productivity (TFP) provides evidence of technological improvement in the sample period. However, this improvement is not uniform across industries, as some industries showed rapid TFP growth (industries 30: chemical products, and 37: transport equipment), while others showed no evidence of technological improvement (e.g. industry 34: metal products). Second, both factor endowments and technology are strongly associated with the share of an industry in the gross domestic product of a state. Endowments of capital stock, literates and illiterates are more significantly related to industry shares than endowment of agricultural crop area. Factor endowments are much more significantly related to industry share in heavy industries than in textiles and agriculture. One possible explanation is that our measure of crop area does not capture how suitable the land is for food or textile production. We also do not include natural resource endowments, because it is not possible to obtain comparable empirical measures at the state level over time. The state fixed effect which we use in the regression will control for time invariant natural resource endowments. Third, superior technology in an industry is associated with larger shares of that industry. These findings are robust to the inclusion of additional political and market potential controls in the regression. Fourth, there is strong evidence that both rounds of liberalisation of the economy beginning in 1985 and 1991 are associated with structural breaks in the relationship between factor endowments, technology, and industrial structure.

The rest of this chapter is structured as follows. The next section outlines the empirical environment, providing a description of the data and the industrial policy of India. This is followed in section 3.3 by the empirical model used. Section 3.4 details the results, and section 3.5 concludes.

3.2 Empirical environment

This section first outlines the institutional environment in which the empirical exercise is carried out, then offers a description of the data used.

3.2.1 Industrial policy and economic performance in India

The data which we use for our empirical study spans the period 1980-1997, covering both sides of the economic reform begun in India hesitantly in the mid-1980s and more broadly in 1991. Industrial licensing was a central part of industrial policy in India prior to reform. The Industries (Development and Regulation) Act of 1951 imposed a licensing requirement on private industry in almost all industries. A licence was required to set up a new unit, expand capacity by more than 25 percent, or manufacture a new product.

Prior to the major reform of 1991, industrial policy was governed by the Industrial Policy Resolution of 1956. Under this resolution, "... the State will progressively assume a predominant and direct responsibility for setting up new industrial undertakings and for developing transport facilities." (Government of India (1956)). This is clearly a statement on the role of state planning in industrial development in the pre-reform period; its purpose was "to prevent private monopolies and the concentration of economic power in different fields in the hands of small numbers of individuals". All industries were divided into three categories: those which were to be the exclusive responsibility of the state, those which were to be progressively state-owned, and those left to private enterprise. Included in the first two categories was virtually every heavy industry. The resolution goes on to state, "In order that industrialisation may benefit the economy of the country as a whole, it is important that disparities in levels of development between different regions should be progressively reduced". However, the resolution recognises that existing concentrations of industrial activity are often determined by factor endowments and infrastructure. Hence it also seeks to develop such facilities in underdeveloped regions. All in all, the tone of the 1956 Resolution is one of state dominance in industry, with the private sector relegated to secondary importance.

In 1985 and 1986, Rajiv Gandhi's government initiated a set of policies to liberalise the Indian economy. Industrial licensing was abolished for 25 broad industry groups. Licensing requirements for capacity expansion and product diversification were relaxed. Import tariffs were also reduced.

India's economic performance from 1950 to 1980 was not impressive, with commentators ranging from Das (2002) to Srinivasan (2003) referring to the "Hindu rate of growth" of 3.5 percent per year (in real terms) in that period. Economic growth improved in the 1980s, to a real average growth rate of 5.7 percent (and further improved to 6.2 percent per year in the 1990s). Rodrik and Subramanian (2004) argue that this improvement in growth rates in the 1980s was largely caused by the pro-business orientation of Indira Gandhi when she returned to power in 1980. At least some part of this improvement may be attributed to the limited liberalisation begun in 1985 by Rajiv Gandhi, and also by fiscal expansion in the second half of the 1980s (see Panagariya (2004)).

In 1991, India began further liberalisation of its economy. This liberalisation was initiated by the incoming government as a result of a balance of payments crisis in 1991, which in turn was caused by fiscal imbalances throughout the 1980s. Because the reform was caused by a crisis, initial reforms were focussed on macroeconomic stabilisation. Simultaneously, reform was begun in industrial policy, trade and exchange rate policies, foreign investment policy, taxes, the financial sector, and the public sector. These measures were much more comprehensive than those implemented by Rajiv Gandhi in 1985.

The tone of the Statement of Industrial Policy 1991, coinciding with the reform of the economy in 1991, is substantially different from that of the 1956 Resolution. It recognises that, in public sector enterprises, "(s)erious problems are observed in the insufficient growth in productivity, poor project management, over-manning, lack of continuous technological upgradation, and inadequate attention to R&D and human resource development" (Government of India (1991)). The Statement calls for a reduction in the number of industries reserved for the public sector, to those related to the military, fuels, mining, and railroads, and also for the abolishment of industrial licensing for almost all other industries. The limit on investments in large Indian and foreign companies was scrapped for many high-priority, advanced technology industries, and access to foreign technology was made much easier. Overall, it is a statement of industrial liberalisation.

The reform from a state-led economic system to a more free-market system has implications for our empirical strategy to be detailed in section 3.3. Our empirical strategy assumes free, competitive markets. This poses no difficulty if the state, in implementing its planning decisions, is a benevolent social planner which seeks to maximise social welfare, and there are no distortions in the economy. If that is the case, then the market outcome simply replicates the planning outcome. However, it seems more likely that the state has other interests in addition to social welfare. Theory does not offer much guidance on how this affects the relationship between factor endowments and industrial structure. It may even be the case that government intervention had no impact on this relationship, since as noted above the government had the intention of changing capital and infrastructural endowments in parallel with redistributing industrial production. We include a direct measure of state policies in the form of labour regulation, and measures of the political histories of states to control for other ways in which government policy may influence industrial structure. In addition, one of our empirical strategies is to include a set of terms interacting a post-reform dummy with factor endowment measures. Then, the statistical significance of the coefficients on these terms would enable us to determine whether the relationship between factor endowments, technology and industral structure, differs between state planning and market allocation.

3.2.2 Data

The main dataset that we use comes from the Annual Survey of Industries (ASI), produced by the Central Statistical Organisation of India. The ASI is a survey of registered manufacturing firms; that is, firms that have either (1) 20 or more workers without electrical power, or (2) 10 or more workers with electrical power[18]. This annual publication consists of data at the 3-digit level at the state level. This gives us a total of 138 industries. The total number of industry-state-time observations is 30676. Because of confidentiality restrictions, some small industries do not appear in the dataset for each period. Since this would affect our TFP estimates, we retain in our sample only those industries which appear in every year. This reduces the total number of industry-state-time observations from 30676 to 18000.[19]

We then aggregate up to the two digit level, since factor endowment differences may be more important in determining the mix of broad industry aggregates. We further combine industries 24 and 25 into a single industry for the manufacture of all textiles

[18] Throughout this chapter and the next, we use the term "manufacturing" to mean registered manufacturing. The ASI contains only data for registered manufacturing; any data on unregistered manufacturing reported below are from Besley and Burgess (2004). However, this data is not available at the industry level.

[19] Including all 3 digit observations in our aggregation, as expected, injects much more noise into the results, especially on TFP. Nevertheless, the basic pattern of the findings holds if all 3 digit observations are retained in the sample.

other than cotton textiles. This is done because industry 25 (manufacture of jute and other vegetable textiles) appears in only a few states, hence the few TFP observations for that industry would prove problematic when running regressions including TFP as an independent variable. We therefore have a total of 18 industries.

There is a total of 25 states and 7 union territories in the sample period (in 2000, the borders of several states were redrawn and three new states created). The analysis is performed on the 16 largest states in terms of industrial output due to data limitations; these states represent over 97 percent of the total population of India. For each industry-state pair, data on a wide range of variables is available, from number of factories, to capital employed, workers employed, total inputs and output, value added, and capital formation. We have data for the period 1980 to 1997, which is an especially interesting period to investigate for the reason mentioned above: the liberalization of the economy, which began somewhat hesitantly in the 1980s, and was rapidly pushed forward in 1991 as a direct result of the financial crisis faced by the Indian government. The sample period is thus one of rapid change and growth of the Indian economy.

Data on endowments comes from a variety of sources; the Data Appendix to this chapter provides further details on sources and construction of data. A key source of data is the dataset compiled by Ozler, Datt and Ravallion (1996), augmented by Besley and Burgess (2000, 2004), and further extended by the author using data from the Statistical Abstract of India (various years); see Besley and Burgess (2000, 2004) for further details on the data. Key data sources include the Census of India for population figures, and Butler, Lahiri and Roy (1991) for political variables. Data for transport networks are from the Statistical Abstract of India.

Factor endowments

Table 3.1 provides summary statistics of factor endowments. We use four measures of factor endowments: capital stock, number of literates and illiterates in the population (to capture skilled and unskilled workers), and crop area. Our capital variable is real fixed capital. On a per capita basis, this varies in 1980 from less than 100 rupees per capita in Assam, Jammu and Kashmir and Uttar Pradesh, to over 400 rupees per capita in Gujarat and Maharashtra. A similar pattern can be observed in 1997, giving no indication of convergence in real capital-labour ratios. This is consistent with recent studies which find evidence of only conditional convergence in growth rates and polarisation in income levels across Indian states (see Trivedi (2002) and Bandyopadhyay (2004)).

Capital accumulation in India has been extremely rapid over the sample period, apart from Bihar where the capital-labour ratio actually decreased between 1980 and 1997. On average, each state had almost four times as much real fixed capital per capita in 1997 as it did in 1980, with Gujarat posting the largest increase of almost seven times the 1980 real per capita capital stock.

Population and population growth rates also vary significantly across states. The most populous state, Uttar Pradesh, has close to 156 million people in 1997, and while we have omitted the smallest states and union territories from our sample, the smallest states in our sample in terms of population are Jammu and Kashmir and Haryana, which have 8.9 million and 18.9 million people respectively. In terms of growth rates, there are states with relatively low growth rates (Tamil Nadu and Kerala where the population grew 23.5 percent and 25.6 percent respectively between 1980 and 1997), and also states with high growth rates such as Jammu and Kashmir and Rajasthan where the increase in population over the sample period was 50.2 percent and 48.9 percent respectively.

With the increasing population and the much slower increase (and occasional declines) in the area under crops, cropped area per capita is declining in every state in India. Finally, since the skill level of the workforce is an important endowment, we have figures for literacy rates. There is a positive correlation between literacy rates and real per capita SDP (correlation is between 0.31 and 0.55 for each year). In terms of percentages, literacy rates range from 23.9 percent in Rajasthan in 1980 to 69.4 percent in Kerala in 1980, and from 45.1 percent in Bihar in 1997, to 90.5 percent in Kerala in 1997.

	Real fixed capital (million rupees)*		Real per capita fixed capital (rupees)		Area under crops (000 hectares)		Per cap cropped area (hectares)		Real per capita net SDP (rupees)		Population (000)		Literacy rate	
State name	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997
Andhra Pradesh	8675	60000	163.44	807.06	12281	13777	0.2314	0.1854	1473.9	3445.9	53077	74324	29.37	54.27
Assam	795	3561	44.42	138.44	3446	3979	0.1926	0.1547	1380.4	2126.9	17893	25721	39.64	59.77
Bihar	26900	35100	388.7	353.46	11148	10262	0.161	0.1033	984.6	1445	69242	99309	25.57	45.09
Gujarat	17000	175000	502.18	3774.6	10695	11064	0.3169	0.2387	2073.5	5291	33754	46358	42.91	66.38
Haryana	4441	25300	347.15	1342.12	5462	6174	0.427	0.3271	2533.6	5738.8	12793	18878	35.18	63.55
Jammu & Kashmir	34	110	5.7	12.58	974	1081	0.1648	0.1214	1927.8	2464.5	5910	8907	25.89	48.91
Karnataka	8781	42800	238.94	863.55	10660	12712	0.2901	0.2565	1623.9	3805.1	36750	49560	37.8	62.62
Kerala	4330	10600	170.76	331.91	2862	2974	0.1129	0.0934	1620.5	3873	25357	31839	69.4	90.55
Madhya Pradesh	13700	43300	264.67	575.4	21402	25862	0.4143	0.3439	1463.1	2514.2	51655	75200	27.32	56.23
Maharashtra	27500	183000	441.32	2044.9	20270	22117	0.3256	0.2468	2603.2	5979.4	62263	89612	46.4	72.36
Orissa	4249	7751	162.12	217.61	8746	6764	0.3337	0.1899	1420.4	2084.9	26210	35619	33.4	57.77
Punjab	5682	19000	341.52	829.04	6763	7932	0.4065	0.3453	2858.6	6348.7	16638	22969	40.18	65.17
Rajasthan	4053	33500	120.02	666.42	17350	21714	0.5138	0.4317	1313.2	3035.9	33771	50293	23.87	52.22
Tamil Nadu	12600	74000	260.91	1243.32	6469	6646	0.1343	0.1117	1601.4	4229	48184	59513	46.07	69.28
Uttar Pradesh	8805	76900	80.28	494.08	24574	26465	0.2241	0.1699	1365.7	2364.8	109677	155723	26.65	51.65
West Bengal	13000	42100	240.3	554.92	7620	9145	0.1409	0.1205	1894.2	3460	54100	75864	40.13	64.73

* Base year 1981. Figures for capital stock in West Bengal in 1997 are actually for 1996 as data for 1997 is unavailable.

Table 3.1: Descriptive statistics.

Share of industries

Section 3.3 develops the neoclassical model from which is derived the main estimation equation. The model predicts that the share of an industry in state GDP is associated with factor endowments, technology, and prices. This industry share, measured at the 2-digit level, is the dependent variable in our regression.

Table 3.2 presents data on the share of registered manufacturing in each state in SDP, for 1980, 1991 and 1997, while Figure 3.1 presents the time series of this share (each state rescaled to show changes over time more clearly). What is clear from both the table and the figure is the difference across states in terms of share of SDP in registered manufacturing. This ranges from approximately 2 percent in Jammu and Kashmir, to over 15 percent in Gujarat, Maharashtra and Tamil Nadu.

There are also changes in this share over time. Despite the rapid growth of the Indian economy over the sample period, the share of registered manufacturing does not seem to have increased very much over time. Only four states posted large increases in the registered manufacturing share of SDP: Andhra Pradesh, Gujarat, Haryana and Punjab. West Bengal exhibited falling registered manufacturing as a share of SDP. In general, state industry share tends to follow the same trend before and after the reform; notable exceptions are Gujarat and Haryana, where industry share increased dramatically post-reform, and Karnataka, where industry had been increasing as a share of SDP before reform, but this trend has been reversed post-reform. Such changes in manufacturing share could also reflect changes in performance in other sectors; for example, some states may have experienced rapid increases in non-manufacturing growth post-reform.

Figure 3.2 shows the time path of the share of the different sectors in the Indian economy. We define the primary sector as agriculture, forestry, fishing and mining; the secondary sector as total manufacturing (registered plus unregistered); the tertiary sector as services, comprising transport, storage and communication, trade, hotels and restaurants, banking and insurance, real estate, business services, and other services; and other sectors as construction, electricity, water and gas, and public administration. The biggest change is that the share of the primary sector has declined over time, from 43.2 percent of national income in 1980, to 32.6 percent in 1997. Much of this decline has been re-

State name	Share of registered manufacturing in SDP		
	1980	1991	1997
Andhra Pradesh	5.85	9.57	9.49
Assam	4.16	7.44	4.84
Bihar	3.45	9.15	7.19
Gujarat	15.11	14.10	26.04
Haryana	10.05	10.53	16.27
Jammu & Kashmir	1.34	1.70	2.70
Karnataka	9.06	10.48	9.43
Kerala	7.59	8.22	7.64
Madhya Pradesh	6.86	6.16	10.64
Maharashtra	19.13	17.73	17.22
Orissa	4.74	7.25	5.34
Punjab	5.91	7.82	8.86
Rajasthan	4.83	6.53	5.23
Tamil Nadu	14.95	16.42	14.56
Uttar Pradesh	4.34	7.87	7.54
West Bengal	12.16	7.10	6.50

Note: The value for Jammu and Kashmir for 1997 is the 1996 value.

Table 3.2: Share of registered manufacturing in SDP

Figure 3.1: Share of registered manufacturing in state domestic product.

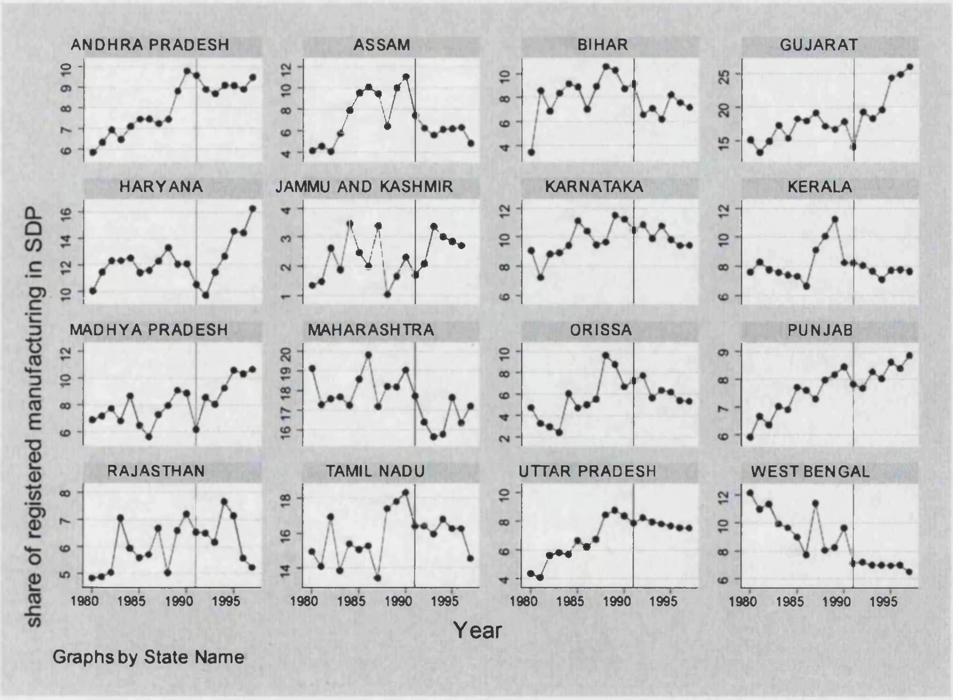
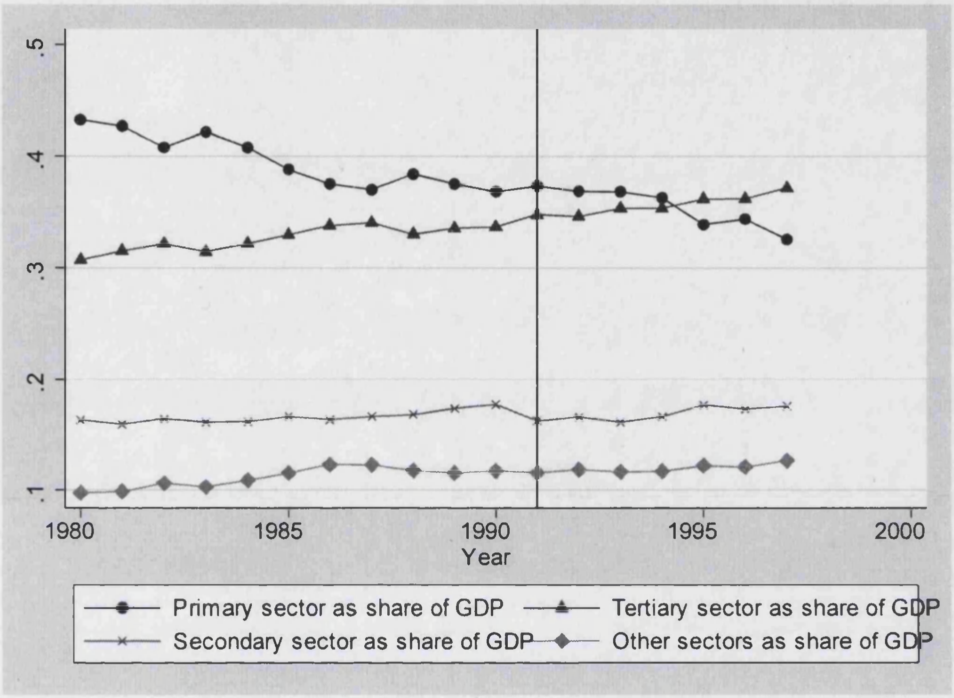


Figure 3.2: Components of state domestic product.

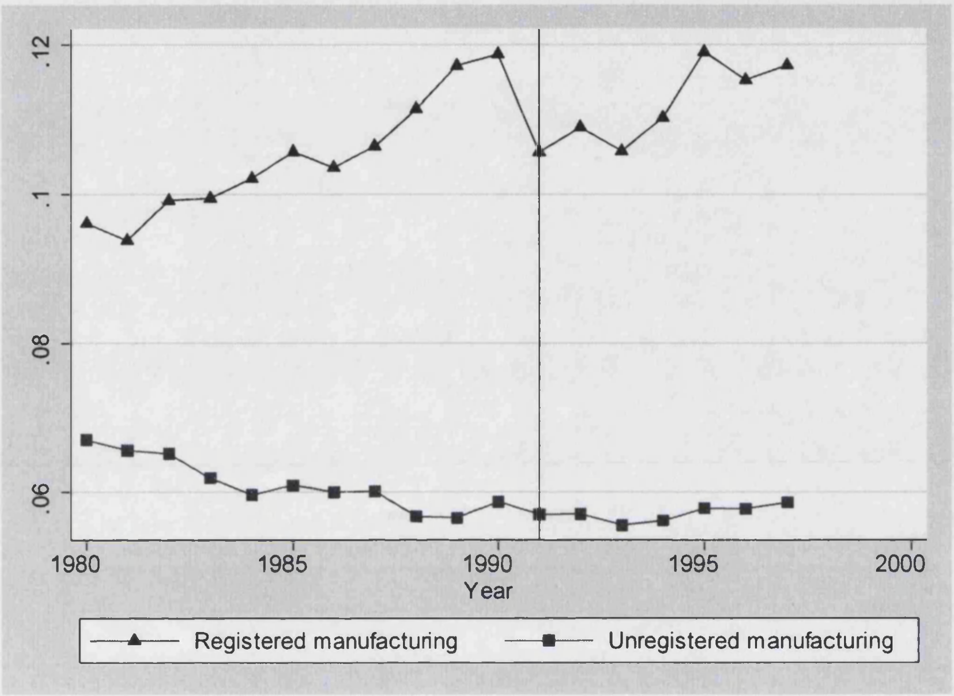


placed by an increase in the tertiary sector, which increased as a share of national income from 30.7 percent in 1980 to 37.2 percent in 1997. The share of the secondary (manufacturing) sector increased only slightly in this time period, from 16.3 percent in 1980 to 17.6 percent in 1997. The share of other sectors increased from 9.8 percent to 12.7 percent. The evidence suggests that economic growth in India over the sample period was not primarily driven by manufacturing growth, but by a switch from primary sector activities such as agriculture and mining, to tertiary sector activities such as transport and communication, financial and other services.

Figure 3.3 disentangles manufacturing into registered and unregistered manufacturing. We find that registered manufacturing as a share of state domestic product was increasing (and the share of unregistered manufacturing was decreasing) before the reform of 1991. These shares appear to have stabilised post-reform, at about 11 percent for registered manufacturing, and 6 percent for unregistered manufacturing.

Turning to industry-level data for registered manufacturing, the share of 2-digit industries in total registered manufacturing also varies considerably across states and

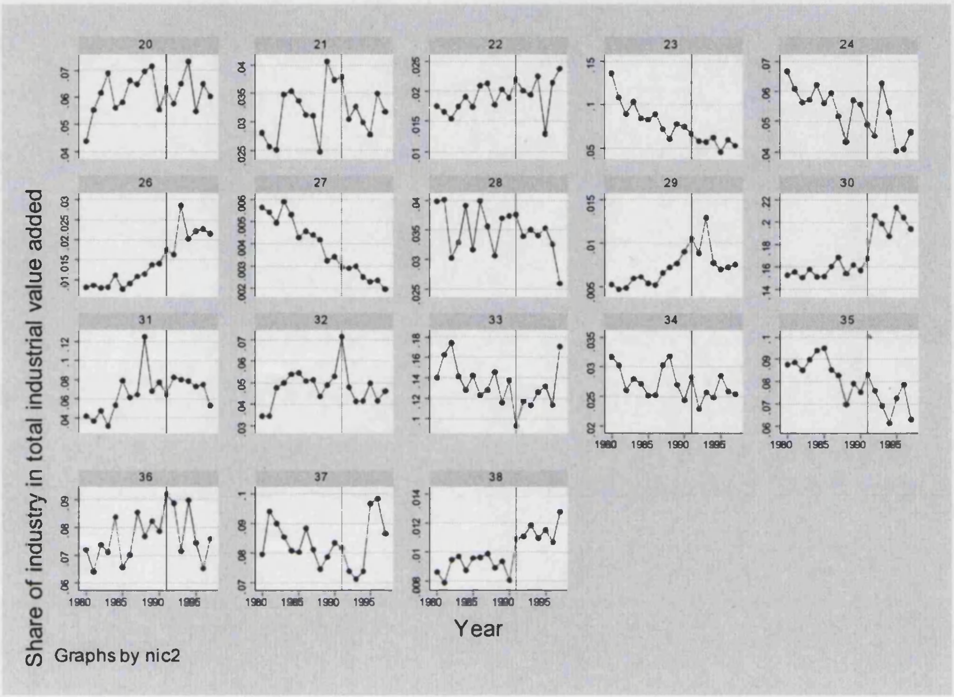
Figure 3.3: Time path of registered and unregistered manufacturing as share of state domestic product.



over time. Consider for example, industry 20 (food products). In 1980 the share of this industry in total industrial value added varied across states from less than 2 percent in Madhya Pradesh, Maharashtra, Rajasthan and West Bengal, to over 10 percent in Andhra Pradesh, Jammu and Kashmir, Punjab, and Uttar Pradesh. Similar patterns can be found in different years and in different industries, sometimes to an even greater extent. For instance, almost 80 percent of manufacturing value added in Assam can be attributed to industry 21 (food products), while over 50 percent of manufacturing value added in Orissa consists of industry 33 (basic metals and alloys).

At the national level, the performance of individual 2-digit industries is equally varied. Figure 3.4 shows the share of each 2-digit industry in total industrial value added (individually scaled to show fluctuations in industry share more clearly). While most industries seem to have maintained their share of industrial value added, industries 23 and 27 (cotton textiles, and wood products) show decreasing shares over time, while industry 26 (textile products) experienced an increasing share over time.

Figure 3.4: Share of industry in country-wide registered manufacturing.



Going into the details, there is also great variation in the time paths of the shares of industries in states and states in industries over time. In terms of "emergent" or rapidly growing industries, the best examples are industry 26 (textile products) in Karnataka and Tamil Nadu, and industry 37 (transport equipment) in Haryana.[20] Rapidly declining industries include industries 22 (beverages and tobacco) and 23 (cotton textiles) in Gujarat, industry 24 (man-made textiles) in Andhra Pradesh, industry 27 (wood products) in Maharashtra, and industry 33 (metals and alloys) in Kerala and Rajasthan..

3.2.3 Summary: Empirical environment

The ideas to be drawn from this description of the data are twofold: First, there is a great variety of experiences across states and over time in India, both in terms of factor endowments and the performance of industries, both individually and in the aggregate.

[20] The much-discussed IT boom in Bangalore in Karnataka is lost in the coarseness of the industrial classification, and in the fact that a large proportion of the activities of the IT sector fall under services rather than manufacturing.

This leads to the second idea, which is what motivates this chapter: are the variations in factor endowments related to the variation in industrial performance?

3.3 Empirical Strategy

This section first outlines the theoretical background of the model, then presents the econometric specification, followed by a discussion of the measurement issues associated with calculating Total Factor Productivity, and estimation methods.

3.3.1 Factor endowments and technology

The model is derived from neoclassical trade theory. We consider first the basic specification. This makes the usual assumptions of constant returns to scale and perfect competition, and identical preferences across states. However, we allow for technology differences across states and industries. States are indexed by $z \in \{1, ..., Z\}$, goods by $j \in \{1, ..., N\}$, factors of production by $i \in \{1, ..., M\}$, and time by t.

Each state is endowed with an exogenous vector of factors of production, v_{zt}. We assume Hicks-neutral technology differences such that the production function takes the form (see Dixit and Norman (1980) p. 138) $y_{zjt} = \theta_{zjt} F_j (v_{zjt})$, where θ_{zjt} is the level of technology in industry j in state z in year t. The Hicks-neutral technology implies that technological differences affect the productivity of all factors of production in industry j in state z by the same proportion. The revenue function $r(\theta_{zt} p_{zt}, v_{zt})$ characterises general equilibrium in production, where θ_{zt} is an $N \times N$ diagonal matrix of the technology parameters θ_{zjt}. As long as the revenue function is twice continuously differentiable, the vector of net output supplies $y(\theta_{zt} p_{zt}, v_{zt})$ is given by the gradient of $r(\theta_{zt} p_{zt}, v_{zt})$ with respect to p_{zt}.[21]

[21] A sufficient condition for the revenue function to be twice continuously differentiable and production patterns to be determinate is that there are at least as many factors as goods: $M \geq N$. If there are more goods than factors, $N > M$, production structures may still be determinate if there are differences in technologies or relative prices across states. If the production structure is indeterminate, then our estimated equation will perform poorly in explaining industry share across states, in terms of having statistically insignificant right-hand side variables.

We follow Harrigan (1997) and Redding and Vera-Martin (2004) in assuming a translog revenue function, which is a flexible functional form that provides an arbitrarily close local approximation to any true underlying revenue function:

$$\begin{aligned}\ln r\left(\theta_{zt}p_{zt}, v_{zt}\right) &= \beta_{00} + \textstyle\sum_j \beta_{0j} \ln\left(\theta_{zjt}p_{zjt}\right) + \frac{1}{2}\sum_j \sum_k \beta_{jk} \ln\left(\theta_{zjt}p_{zjt}\right) \ln\left(\theta_{zkt}p_{zkt}\right) \\ &+ \textstyle\sum_i \delta_{0i} \ln\left(v_{zit}\right) + \frac{1}{2}\sum_i \sum_h \delta_{ih} \ln\left(v_{zit}\right) \ln\left(v_{zht}\right) \\ &+ \textstyle\sum_j \sum_i \gamma_{ji} \ln\left(\theta_{zjt}p_{zjt}\right) \ln\left(v_{zit}\right)\end{aligned} \quad (3.1)$$

where $j, k \in \{1, ..., N\}$ index goods and $i, h \in \{1, ..., M\}$ index factors. Symmetry of cross effects requires that, for all j, k, i and h:

$$\beta_{jk} = \beta_{kj} \qquad \text{and} \qquad \delta_{ih} = \delta_{hi} \quad (3.2)$$

Linear homogeneity in v and p requires:

$$\textstyle\sum_j \beta_{0j} = 1 \quad \sum_i \delta_{0i} = 1 \quad \sum_j \beta_{jk} = 0 \quad \sum_i \delta_{ih} = 0 \quad \sum_i \gamma_{ji} = 0 \quad (3.3)$$

Differentiating $\ln r\left(\theta_{zt}p_{zt}, v_{zt}\right)$ with respect to each $\ln p_j$ gives the share of good j in GDP as a function of prices, technology and factor supplies:

$$S_{zjt} = \frac{p_{zjt}y_{zjt}\left(\theta_{zt}p_{zt}, v_{zt}\right)}{r\left(\theta_{zt}p_{zt}, v_{zt}\right)} = \beta_{0j} + \textstyle\sum_j \beta_{jk} \ln\left(p_{zjt}\right) + \sum_j \beta_{jk} \ln\left(\theta_{zjt}\right) + \sum_i \gamma_{ji} \ln\left(v_{zit}\right) \quad (3.4)$$

This is a general equilibrium relationship between industry shares and prices, endowments and technology. Changes in the RHS variables have different effects in different industries, as captured here by the industry-specific coefficients.

Alternatively, imposing the assumption of identical technology across states as in the Heckscher-Ohlin model gives the following relationship between industry shares and prices and factor supplies:

$$S_{zjt} = \beta_{0j} + \textstyle\sum_j \beta_{jk} \ln\left(p_{zjt}\right) + \sum_i \gamma_{ji} \ln\left(v_{zit}\right) \quad (3.5)$$

3.3.2 Econometric specification

We first start with the specification with identical technology, and write equation (3.5) as:

$$S_{zjt} = \beta_{0j} + \textstyle\sum_j \beta_{jk} \ln\left(p_{zjt}\right) + \sum_i \gamma_{ji} \ln\left(v_{zit}\right) + \varepsilon_{zjt} \quad (3.6)$$

where ε_{zjt} is a random error. Equation (3.6) is estimated for each industry, pooling observations across states z and time t. However, one problem with estimating (3.6) is that prices of individual industries are not observable across states.

If we assume that all goods are perfectly tradeable, then prices are equalized across states, and we can get around the problem of unobservable prices by adding a set of industry-specific time dummies ζ_{jt} to control for differences in prices across industries and time:

$$S_{zjt} = \beta_{0j} + \zeta_{jt} + \sum_i \gamma_{ji} \ln(v_{zit}) + \varepsilon_{zjt} \tag{3.7}$$

These industry-specific time dummies also control for industry-specific shocks that are common across states.

To allow for non-tradeables, first we partition the vector of goods prices p_{zt} into the vectors of tradeable (p_{zt}^T) and non-tradeable (p_{zt}^{NT}) goods prices:

$$p'_{zt} = (p_{zt}^T : p_{zt}^{NT})'$$

where p_{zt}^T is an $1 \times n^T$ vector of traded goods prices, p_{zt}^{NT} is an $1 \times n^{NT}$ vector of non-traded goods prices, and $n^T + n^{NT} = n$. Since free trade still allows equalized goods prices among tradeables, while in general we have different non-traded goods prices, we can write equation (3.6) as:

$$S_{zjt} = \beta_{0j} + \zeta_{jt} + \sum_{j=n^T+1}^{n} \beta_{jk} \ln(p_{zjt}^{NT}) + \sum_i \gamma_{ji} \ln(v_{zit}) + \varepsilon_{zjt} \tag{3.8}$$

Since we once again do not have data on the prices of non-tradeables, we follow Harrigan (1997) and Redding and Vera-Martin (2004) in treating the price of non-traded goods as a random variable with some estimable probability distribution. Thus, let

$$\sum_{j=n^T+1}^{n} \beta_{jk} \ln(p_{zjt}^{NT}) = \eta_{zj} + \mu_{jt} + u_{zjt} \qquad u_{zjt} \sim N(0, \sigma_j^2) \tag{3.9}$$

such that the price of non-traded goods comprises state-industry fixed effects η_{zj}, industry-specific time dummies μ_{jt}, and a random component u_{zjt} with constant variance σ_j^2. Combining equations (3.8) and (3.9), we get:

$$S_{zjt} = \beta_{0j} + \eta_{zj} + d_{jt} + \sum_i \gamma_{ji} \ln(v_{zit}) + \omega_{zjt} \tag{3.10}$$

where $\omega_{zjt} = \varepsilon_{zjt} + u_{zjt}$, and $d_{jt} = \mu_{jt} + \zeta_{jt}$ is the combined time-specific effect of all goods prices and nontraded goods technology parameters. The state-industry fixed effect η_{zj} will also control for unobserved time-invariant differences across states that are allowed to have heterogeneous effects across industries. Equation (3.10) is the first estimated equation.

Alternatively, if instead of starting from (3.5), we begin developing our empirical framework from (3.4) exploiting the Hicks-neutral technology differences across states, then the analogue to equation (3.10) would be:

$$S_{zjt} = \beta_{0j} + \eta_{zj} + d_{jt} + \sum_j \beta_{jk} \ln(\theta_{zjt}) + \sum_i \gamma_{ji} \ln(v_{zit}) + \omega_{zjt} \qquad (3.11)$$

This is Harrigan's (1997) equation (5), and is the second equation which we estimate. The advantage of using equation (3.11) rather than equation (3.10) is that, with equation (3.11), we can evaluate the relationship between both factor endowments and technology, and industry share across industries, states, and time. Technological differences may have a strong association with industrial structure and may be correlated with factor endowments, in which case the parameter estimates from estimating equation (3.10) would be biased and inconsistent, due to the omitted variables.

3.3.3 Total factor productivity

In estimating equation (3.11), we also need a measure of θ_{zjt}, the Hicks-neutral technology parameter. We calculate net–value-added (NVA) based total factor productivity (TFP) indices, using data on NVA, labour input and capital input. All values are deflated using industry-level price deflators; this deflation enables us to focus on changes in efficiency as opposed to changes in prices which may affect across-time comparisons, although we are unable to disentangle technological improvements against other reasons for efficiency gains. Deflating NVA in this way also implicitly assumes that intermediate-input and output prices are changing at the same rate; we therefore cannot control for changes in mark-ups[22].

Thus, suppose that value added NVA is a function of capital k and labour l. Suppressing industry and time subscripts for readability, for any given industry-time pair, the

[22] One possible way to control for changes in mark-ups is to use a double-deflation method to calculate output-based TFP. This involves using different deflators for inputs and outputs. We do not have the data to calculate TFP in this way.

index for any two states x and z is:

$$TFP_{xz} = \frac{NVA_x}{NVA_z}\left(\frac{\bar{l}}{l_x}\right)^{\sigma_x^l}\left(\frac{\bar{k}}{k_x}\right)^{1-\sigma_x^l}\left(\frac{l_z}{\bar{l}}\right)^{\sigma_z^l}\left(\frac{k_z}{\bar{k}}\right)^{1-\sigma_z^l} \tag{3.12}$$

where $\bar{l}$ and $\bar{k}$ are geometric averages over all the observations in the sample, $\sigma_z^l = \left(s_z^l + \bar{s}^l\right)/2$, where s_z^l is labour's share in output in state z. We calculate TFP relative to the geometric mean for each industry, so that, for state z, equation (3.12) simplifies to:

$$TFP_z = \frac{\overline{NVA}}{NVA_z}\left(\frac{l_z}{\bar{l}}\right)^{\sigma_z^l}\left(\frac{k_z}{\bar{k}}\right)^{1-\sigma_z^l}. \tag{3.13}$$

This is the equation that is used to calculate TFP. It is a general superlative index number measure of TFP, meaning that it is exact for the flexible translog form.[23] Since the share of labour is relatively noisy and sometimes exceeds one, we follow Harrigan (1997) in using a smoothing procedure. When the production function is translog and markets clear, labour's share in NVA of industry j at time t in state z is:

$$s_{zjt}^l = \alpha_{1zj}^l + \alpha_{2j}^l \ln\left(\frac{k_{zjt}}{l_{zjt}}\right) \tag{3.14}$$

If observed labour shares deviate from this equation by an i.i.d. error term, then the parameters of this equation can be estimated for each industry by regressing the share of labour on a set of state fixed effects and the capital-labour ratio. The fitted values from this equation are then used as the labour cost shares in the TFP equation (3.13).

3.3.4 Estimation

There are a couple of econometric issues to address. The first is the estimation method used. Since we control for both time and state fixed effects, identification of the parameters of interest in equations (3.10) and (3.11) (i.e. the parameters on factor endowments and technologies) is through within-state time series variation.

The translog revenue function implies the presence of cross-equation restrictions on the coefficients on TFP in the model with TFP $\left(\beta_{jk} = \beta_{kj}\right)$. These cross-equation restrictions imply that the errors are correlated across equations. Therefore, the appropriate way to estimate the system of equations is to use a restricted SURE (seemingly unrelated regressions) estimator. The resulting GLS estimator is asymptotically efficient if the re-

[23] Caves, Christensen and Diewert (1982a, 1982b) show how we can obtain the productivity index (3.12). Diewert (2000) is a highly readable discussion of measuring total factor productivity. Griffith, Redding and Van Reenen (2004) consider alternative ways of measuring TFP.

strictions are valid (see Baltagi (1995) pp. 103-104 for a description). Also, in both equations (3.10) and (3.11), we can impose the linear homogeneity assumptions above (equation (3.3)), since these conditions must hold in the model. This leads quite naturally to a test of whether the production function is constant returns to scale. In terms of the model, this is a test of whether the revenue function is homogeneous of degree one, or equivalently that the sum of the factor endowment coefficients is equal to zero $\left(\sum_i \gamma_{ji} = 0\right)$ in an unconstrained version of the model.

As a robustness check on our results, we include additional explanatory variables in the regression to control for income levels, politics and market access. We also conduct tests for parameter stability over time, to test for changes in the impact of endowments and technology on industry shares caused by economic reform in 1985 and 1991. As discussed below in subsection 3.4.4, this is done by including a set of interaction terms, interacting a reform dummy with the RHS variables, and performing an F-test on the joint significance of these interaction terms.

In our empirical work, factor endowments are used as exogenous variables that explain the share of an industry in a state. However, if factors of production are mobile across locations, it is also possible that these endowments may be endogenously determined; that is, changes in production structure can lead to changes in factor endowments. But even if this is the case, there would still exist a relationship between factor endowments and industrial structure which we are able to estimate; what changes is the interpretation of the estimated equation. If factor endowments are exogenously given, the estimated equation has a supply-side interpretation: factor endowments determine the shares of industries, whereas if factor endowments are endogenously determined, the estimated equation has a demand-side interpretation: industry share influences the location of factor endowments. We do not distinguish between these two interpretations, and therefore we cannot interpret our results as representing causal relationships between the variables; this limitation should be borne in mind when reviewing the econometric results below. See Redding and Vera-Martin (2004) for further discussion of this issue.

3.4 Results

3.4.1 Total factor productivity

The total factor productivity data is summarised in Tables 3.3 and 3.4, and Figures 3.5 and 3.6. A clear result of the tables and the figures is the great heterogeneity in performance across industries and states. From Figure 3.5 we can see that some industries are experiencing rapid improvements in technology, such as industries 20 (food products), 29 (leather products), 30 (basic chemicals), 37 (transport equipment) and 38 (other manufacturing). Many of the other industries do not appear to have experienced much change in TFP over the sample period. In industry 26 (textile products), TFP has actually declined in the post-reform period.

If we look at the mean of relative TFP across all industries over time (Figure 3.6), we find that TFP has been increasing over time, from 0.869 in 1980 to 1.363 in 1997. This corresponds to an average growth rate of almost 2.7 percent, which is similar to the recent results on TFP growth in India by Unel (2003) and Rodrik and Subramanian (2004) for the same time period. While one might think that the liberalisation of the economy would boost TFP growth, visual inspection of Figure 3.6 does not suggest any increase in TFP growth after the reform of 1991. This is also consistent with the results of Aghion, Burgess, Redding and Zilibotti (2004) who find a small mean effect of liberalisation but substantial heterogeneity across states and industries.

Krishna and Mitra (1998) present evidence that productivity growth increased in several industries in the post-reform period in India. This is not inconsistent with our result, as we do find some industries experiencing more rapid TFP growth post-reform, for example industry 37 (transport equipment). Ahluwalia (1991) finds that TFP growth in India has been low throughout the post-independence period, growing by 0.2 percent per year between 1959 and 1966, falling at a rate of 0.3 percent per year betweem 1967 and 1980, and increasing by 3.4 percent per year between 1981 and 1986.

TFP tends to be fairly noisy, a result which is also obtained by Harrigan (1997, 1999) for cross-country data and may be attributable to business-cycle effects. Hall (1988) and Hall (1990) present evidence on the pro-cyclical nature of TFP. Hall (1990) in particular discusses possible explanations for this pro-cyclicality, including factor price movements and mismeasurement of inputs and outputs.

Figure 3.5: Time series of mean TFP, by industry

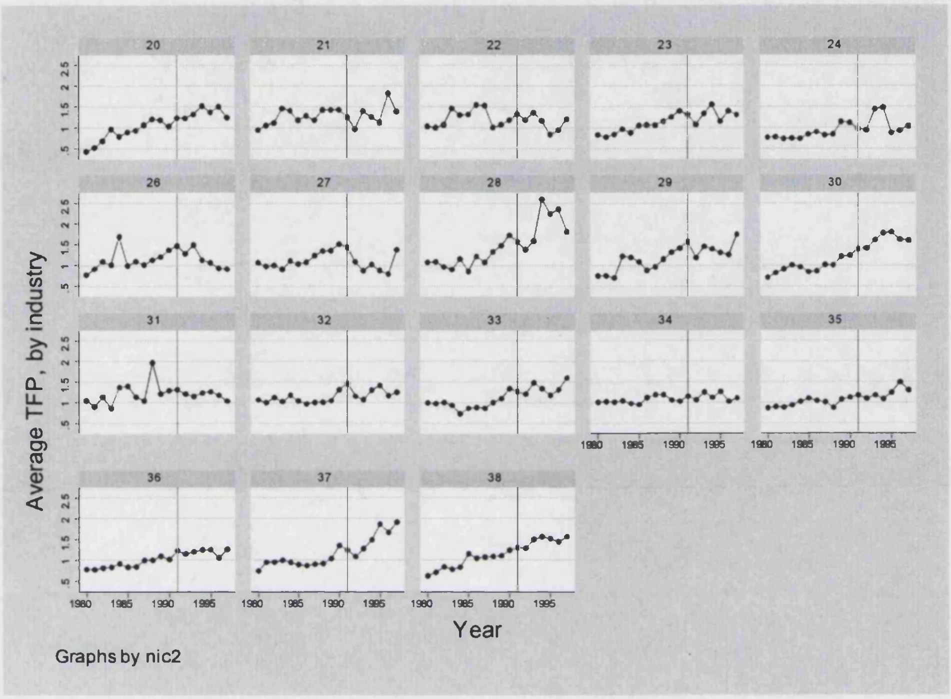
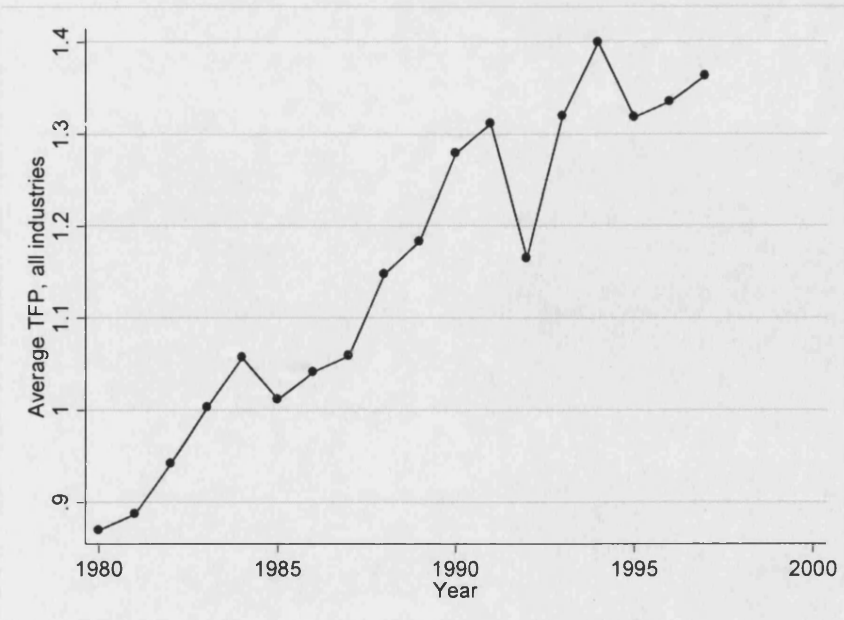


Figure 3.6: Time series of the mean of TFP



	Total factor productivity																	
NIC2	20		21		22		23		24		26		27		28		29	
Year	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997
Andhra Pradesh	0.241	1.022	0.861	1.281	0.579	0.754	0.686	1.469	0.911	1.214	0.091	0.273	0.644	2.983	1.073	2.068	0.571	
Assam	1.395	0.295	0.872	1.041			0.124	1.286					0.994	0.315	1.030	1.567		
Bihar	0.134	1.313	0.488	2.648	1.331	5.766	0.305	0.150					1.233	5.835	1.509	0.255	1.232	1.372
Gujarat	0.500	1.473	0.747	0.734	1.025	0.269	1.033	0.897	0.754	0.547	0.531	0.632	1.039	0.924	0.878	1.517	0.208	1.575
Haryana	0.547	0.174	0.720	0.495	0.760	0.771	0.773	0.857	0.659	0.679	0.660	0.533	1.078	1.523	1.785	1.108	1.700	2.936
Jammu & Kashmir	0.671	2.566																
Karnataka	0.229	1.730	0.741	1.117	1.258	1.620	0.842	2.152	0.422	2.928	0.881	0.878	0.793	0.643	0.902	1.898	0.524	1.476
Kerala	1.028	0.909	1.382	1.788	0.862	1.144	1.234	2.058		0.730	0.511	0.195	0.944	0.407	1.286	1.310		
Madhya Pradesh	0.133	0.934	0.658		1.224	1.494	0.887	2.042	1.006	2.136	1.296	1.312	0.888	0.219	1.098	0.655		
Maharashtra	0.097	0.745	1.341	1.214	0.917	0.622	1.129	0.876	1.038	0.708	0.998	1.115	1.735	0.912	1.417	3.283	0.825	2.858
Orissa	0.307	2.725	0.409	1.008	2.705	0.126	0.610	0.438					1.409	1.855	1.002	2.233		
Punjab	0.580	1.914	1.082	2.246	0.718	0.551	1.019	1.959	0.653	0.741	1.430	1.609	1.011	0.857	0.212	1.841	0.464	0.623
Rajasthan	0.292	2.809	1.004	2.649	0.428	0.079	0.846	0.439	1.110	0.709	0.657	1.567	1.595	2.308	0.900	2.643		
Tamil Nadu	0.463	1.132	0.840	1.587	0.430	2.034	1.309	1.692	0.851	0.530	0.595	0.908	0.959	0.671	1.291	2.574	0.708	0.976
Uttar Pradesh	0.214	1.223	2.517	0.996	0.920	0.992	0.919	1.077	0.218	0.416	0.677	0.615	0.719	0.537	0.757	3.008	0.634	1.810
West Bengal	0.004	0.159	0.585	0.517	1.316	0.471	0.785	2.102	0.791	1.003	0.921	1.283	0.936	0.635	0.964	1.125	0.587	2.044

Notes: The figures for Jammu and Kashmir are for 1980 and 1996. NIC2 is the 2-digit National Industrial Classification, given in Table 3.14. Total factor productivity is calculated for each industry using the following formula:

$$TFP_z = \frac{\overline{NVA}}{NVA_z}\left(\frac{l_z}{\bar{l}}\right)^{\sigma_z^l}\left(\frac{k_z}{\bar{k}}\right)^{1-\sigma_z^l}$$

where NVA is net value added, l is labour, k is capital, and z is the state indicator. All values are deflated using industry-level price deflators. TFP is calculated relative to the geometric mean of the industry over all states. See the Data Appendix for details of the construction and sources of the variables.

Table 3.3: TFP measures relative to industry geometric mean, 1980 and 1997.

	Total factor productivity																	
NIC2	30		31		32		33		34		35		36		37		38	
Year	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997	1980	1997
Andhra Pradesh	0.394	1.248	1.466	0.719	0.862	2.030	0.646	5.160	0.605	0.772	0.704	1.402	0.800	2.327	0.263	1.035	0.692	1.401
Assam					1.800	1.272	0.548	0.836	1.071	1.242	0.894	1.983						
Bihar			1.145	1.065	0.825	0.482	0.401	3.779	0.629	0.558	0.861	0.331	0.247	0.151	1.223	4.092		
Gujarat	0.833	1.753	1.040		0.854	1.672	0.924	0.542	0.960	0.564	0.731	1.069	0.632	0.527	0.506	0.973	0.518	1.302
Haryana		1.640	2.360	1.376	1.302	0.863	1.426	0.403	1.586	1.424	0.959	1.954	0.903	0.950	1.007	3.186	0.649	1.643
Jammu & Kashmir	0.799	0.008					0.786		0.508	0.592			0.217	0.705			0.297	0.623
Karnataka	0.852	1.459	0.283	1.134	0.871	2.079	1.023	0.412	1.188	1.215	1.095	1.031	0.775	1.523	1.204	1.690	1.007	0.810
Kerala	1.047	1.254	0.779	1.244	1.531	0.484	1.538	0.505	0.543	1.135	0.519	2.250	0.970	0.422	0.535	2.591	1.117	2.811
Madhya Pradesh	0.591	3.722	0.297	0.865	0.769	0.939	1.422	3.579	1.039	0.875	1.024	0.667	0.909	1.475	0.514	0.937		
Maharashtra	1.463	3.157	1.040	1.483	1.200	0.485	1.505	1.740	1.756	1.441	1.128	1.373	1.165	1.331	1.045	2.440	0.661	2.228
Orissa	0.710	0.105	1.405	1.009	1.447	1.756	0.997	0.359	0.760	0.590	1.075	0.958	1.196	2.456	0.460	0.911		
Punjab	0.395	1.261	0.763	1.220	0.622	0.882	1.069	0.880	0.888	1.443	0.640	1.575	0.863	1.115	0.729	1.278	0.479	1.132
Rajasthan	0.303	1.273	0.400	0.791	1.194	0.938	1.036		1.341	2.171	1.089	1.106	0.703	0.232	0.671	3.580	0.439	1.190
Tamil Nadu	0.601	0.602	1.487	1.001	0.928	2.795	0.817	1.802	1.329	0.950	0.879	1.022	0.728	1.106	0.875	1.365	0.658	2.021
Uttar Pradesh	0.696	1.911	0.944	0.671	0.504	0.782	0.844	2.082	0.807	1.002	0.566	1.696	0.770	1.840	0.567	1.565	0.284	0.915
West Bengal	0.519	1.376	1.213	0.885	1.285	1.267	0.911	0.308	1.147	1.239	0.852	1.123	0.828	2.222	0.814	1.217	0.758	1.795

Notes: The figures for Jammu and Kashmir are for 1980 and 1996. NIC2 is the 2-digit National Industrial Classification, given in Table 3.14. Total factor productivity is calculated for each industry using the following formula:

$$TFP_z = \frac{\overline{NVA}}{NVA_z}\left(\frac{l_z}{\bar{l}}\right)^{\sigma_z^l}\left(\frac{k_z}{\bar{k}}\right)^{1-\sigma_z^l}$$

where NVA is net value added, l is labour, k is capital, and z is the state indicator. All values are deflated using industry-level price deflators. TFP is calculated relative to the geometric mean of the industry over all states. See the Data Appendix for details of the construction and sources of the variables.

Table 3.4: (continued from Table 3.3): TFP measures relative to industry geometric mean, 1980 and 1997.

A further concern with our TFP measures is that the price deflators which we use to obtain real values is of questionable value in an economy where the artificially low price set by the authorities and the frequent shortage of intermediate inputs led to a flourishing black market for such inputs, where clearly the prices do not follow those set by the authorities. Therefore, the use of official prices will overstate real output, and hence may overstate TFP in the pre-reform period, although this depends on the wedge betweeen official and true prices of both inputs and outputs. This is probably more true in the period before reform, but since the reform was a gradual process, some sectors and prices were probably highly distorted several years after the start of reforms.

It is interesting to compare the TFP growth experience of India with those of China and the East Asian Newly Industrialising Countries (NICs) of Hong Kong, Singapore, Taiwan and South Korea, as these are all countries which have experienced rapid economic growth in the last four decades. Young (1995, 2000) argues that economic growth in China and the NICs was primarily caused by factor accumulation rather than TFP growth.

3.4.2 Basic regression results

Table 3.5 presents the results for equation (3.10), imposing linear homogeneity constraints $\left(\sum_i \gamma_{ji} = 0\right)$ for each industry but not including TFP in the specification[24]. To facilitate comparisons with later results, we report the results for the same number of observations as are used in later samples, where we lose observations because TFP measures are not available for all industries in all years.[25] The reduces the number of observations from a possible 287 to 147.

All results presented include time dummies and state fixed effects (not reported due to space constraints). Because we are estimating general equilibrium effects of the endowments, and because of the linear homogeneity constraint, it is unsurprising that many of the coefficients are negative. For industries 21 (food products), 24 (man-made

[24] The results if the regression is run without imposing the linear homogeneity constraint are broadly similar. Where coefficients are statistically significant in both constrained and unconstrained regressions, they always have the same sign (this is the case for all 20 coefficients which are significant in both regressions).

[25] Table 3.17 in Appendix 3B presents the results with the full sample. Regressing equation 3.10 without TFP using the full sample gives very similar results to the regression with the restricted sample, as all 13 coefficients which are significant in both samples, have the same sign.

textiles), 29 (leather products), 32 (non-metallic mineral products) and 35 (machinery and equipment), factor endowments are not significantly related to industry shares. Industries 21 and 24 are agriculture based and labour intensive, and it is somewhat surprising that the endowments of crop area and unskilled workers have no significant impact. The most likely reason for this is that total crop area is a poor indicator of how much area is suitable for food- or textile-related agriculture. The non-significant relationship between factor endowments and the share of leather products and non-metallic mineral products may be caused by the fact that we do not include natural resource endowments for the reasons noted above. For machinery and equipment, the non-significance of the endowment coefficients is somewhat surprising, especially since this finding is robust to the inclusion of TFP and other control variables. One possible explanation may be that the share of this industry is mainly driven by technological differences across states.[26]

For all other industries, there is at least one factor which has a significant association with industry share at the 10 percent level. In some industries, one or more factor endowments are highly significant; this includes industries 23 (cotton textiles), 34 (metal products), 37 (transport equipment) and 38 (other manufacturing). Apart from cotton textiles, these are mainly heavy industries. Capital stock, literates and illiterates are each statistically significant in between 6 and 8 industries, while crop area is statistically significant in only three industries.

To test the linear homogeneity constraint, we run the regression without imposing the linear homogeneity constraint, and test whether the sum of endowment coefficients is equal to zero. The results are presented at the bottom of Table 3.5. The null hypothesis that the sum of the coefficients is equal to zero is rejected at the 5 percent level for 6 of our 18 industries. In industries 22 (beverages and tobacco), 27 (wood products) and 33 (non-metallic mineral products), the sum of endowment coefficients is positive, suggesting increasing returns to scale, while in industries 26 (textile products), 29 (leather products)

[26] There is evidence of multicollinearity between literates and illiterates; the correlation between these two variables within states and over time is large (sometimes exceeding 0.9). This is not surprising, as literates and illiterates sum to the total state population. This casts doubt over the coefficient estimates of literates and illiterates. However, as Wooldridge (2003) p. 99 shows, high correlation between two explanatory variables does not affect the estimated coefficients on the other variables, if these other variables are not highly correlated with each other or with the multicollinear variables. Therefore, while we may be fairly confident about the coefficient estimates of capital stock and crop area, to obtain precise estimates of the impact of educated workers on industry share, we should drop one of literates or illiterates from the specification.

Dep. Var	(1) share20	(2) share21	(3) share22	(4) share23	(5) share24	(6) share26	(7) share27	(8) share28	(9) share29
Log real fixed capital	0.008	-0.004	0.138	-0.72	-0.056	-0.064	-0.003	-0.111	0.007
	(0.06)	(0.06)	(1.67)+	(2.31)*	(0.33)	(0.55)	(0.22)	(1.37)	(0.13)
Log literates	1.579	0.032	-0.71	-3.814	-0.224	-1.374	0.057	-0.873	-0.422
	(1.94)+	(0.08)	(1.44)	(2.05)*	(0.23)	(1.99)*	(0.83)	(1.80)+	(1.24)
Log illiterates	-1.539	-0.034	0.511	4.53	0.245	1.347	-0.032	0.862	0.401
	(1.72)+	(0.07)	(0.95)	(2.22)*	(0.23)	(1.78)+	(0.43)	(1.62)	(1.08)
Log crop area	-0.049	0.006	0.06	0.005	0.034	0.091	-0.022	0.123	0.014
	(0.57)	(0.14)	(1.15)	(0.02)	(0.33)	(1.24)	(3.00)**	(2.39)*	(0.38)
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.9	0.51	0.88	0.61	0.8	0.91	0.82	0.81	0.81
Sum of endowment coefficients	0.6642	-0.1573	0.8478	0.7119	0.4889	-2.6799	0.1750	-0.0169	-0.6271
p-value	0.2204	0.5742	0.0092	0.5662	0.4580	0.0000	0.0001	0.9583	0.0052
Observations	147	147	147	147	147	147	147	147	147

Dep. Var.	(10) share30	(11) share31	(12) share32	(13) share33	(14) share34	(15) share35	(16) share36	(17) share37	(18) share38
Log real fixed capital	2.094	0.935	0.047	0.939	-0.207	-0.107	-0.366	-0.333	0.054
	(3.81)**	(1.51)	(0.51)	(4.48)**	(2.66)**	(0.65)	(1.78)+	(0.86)	(1.32)
Log literates	-2.617	-8.117	-0.903	1.435	-2.346	0.546	-1.351	15.659	1.273
	(0.80)	(2.20)*	(1.62)	(1.15)	(5.05)**	(0.56)	(1.10)	(6.74)**	(5.22)**
Log illiterates	0.726	7.181	0.843	-2.307	2.572	-0.437	1.856	-15.143	-1.223
	(0.20)	(1.77)+	(1.38)	(1.69)+	(5.05)**	(0.41)	(1.38)	(5.95)**	(4.57)**
Log crop area	-0.203	0	0.012	-0.067	-0.019	-0.001	-0.139	-0.183	-0.105
	(0.58)	(0.00)	(0.20)	(0.50)	(0.38)	(0.01)	(1.07)	(0.74)	(4.04)**
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.78	0.75	0.84	0.86	0.85	0.66	0.68	0.75	0.88
Sum of endowment coefficients	2.7979	-3.7214	0.1386	3.4025	0.4712	-0.1820	0.9808	1.6479	-0.5983
p-value	0.1995	0.1299	0.7096	0.0000	0.1276	0.7800	0.2298	0.2867	0.0002
Observations	147	147	147	147	147	147	147	147	147

Absolute value of t statistics in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. All regressions run using SURE (Seemingly Unrelated Regression) with the restriction that the coefficients on all endowment variables sum to 0. The dependent variable shareXX refers to the share of industry XX in a state's GDP. Real fixed capital is the total depreciated value of fixed assets in industry, deflated by an industry-level price deflator for machinery and transport equipment. Literates and illiterates are the number of people who are literate and illiterate in a state. Crop area is the total area under crops, measured in thousands of hectares. The sum of endowment coefficients is the sum of coefficients on real fixed capital, literates, illiterates and crop area, if the regression is run without imposing the restriction that they sum to zero. The p-value is the p-value of the F-test that the sum of endowment coefficients is equal to zero, when the regression is run without imposing that restriction. See the Data Appendix for details of the construction and sources of the variables.

Table 3.5: Regression (3.10): factor endowments with homogeneity constraints.

and 38 (other manufacturing), the sum of endowment coefficients is negative, suggesting decreasing returns to scale.

Tables 3.6 and 3.7 present the results for equation (3.11), including TFP, and with linear homogeneity and cross-equation constraints on the TFP terms. In Tables 3.6 and 3.7, own-TFP effects are in bold. According to the theory, the own-TFP effect should be non-negative; superior technology in a sector should be positively related to greater share of that industry in the state. We find this to be true in all industries. This coefficient is positive and significant at the 10 percent level in all industries, while in 16 industries it is significant at the 1 percent level.[27]

For cross-industry TFP effects, we get a mix of positive and negative coefficients, as expected, since the underlying model is a general equilibrium model. The results do not correlate closely with those obtained by Harrigan (1997); this is unsurprising since these are general equilibrium effects. With more than two factors and two goods, the predictions of the general equilibrium model hold only as averages or correlations, so that we should not necessarily expect the effects to be the same.

Nevertheless, it is informative to consider the implications of the cross-TFP effects. Positive cross-TFP effects may indicate industries which are complementary to each other, so that superior productivity in one industry, attracts the other industry to locate in that state. On the other hand, negative cross-TFP effects may suggest industries which compete with each other for factors of production, so that superior productivity in one industry, draws resources away from the other industry.

For example, the share of industry 20 (food products) is positively associated with productivity levels in industry 23 (cotton textiles), but negatively assocated with productivity levels in industry 24 (man-made textiles). This may suggest complementarities between the production of food products and cotton textiles, but competition for

[27] There is a potential endogeneity problem with the own-TFP effects, as shocks to own TFP would also affect the share of an industry in GDP. We regressed equation (3.11) using both IV and OLS, instrumenting TFP for each industry in each state, with the average of TFP in that industry across all other states (following Harrigan (1997)). The instrument has high explanatory power in the first stage regression; an F-test of the excluded variables (the average TFPs) is always highly significant at better than 1 percent. A Hausman (1978) test of the null hypothesis that the coefficients do not differ systematically between IV and OLS, cannot be rejected for any industry at any conventional significance level. This suggests that biases due to endogeneity problems are not severe. Another alternative would be to follow Nickell, Redding and Swaffield (2004) in smoothing TFP using a Hodrick-Prescott filter.

Dep. Var.	(1) share20	(2) share21	(3) share22	(4) share23	(5) share24	(6) share26	(7) share27	(8) share28	(9) share29
Log real fixed capital	0.029	-0.083	0.019	-0.623	0.032	-0.081	0.013	-0.016	0.108
	(0.21)	(1.01)	(0.20)	(2.41)*	(0.21)	(0.75)	(0.28)	(0.22)	(1.10)
Log literates	1.359	-0.397	-0.41	-3.694	1.248	-1.119	0.102	-0.9	0.106
	(1.55)	(0.77)	(0.71)	(2.33)*	(1.29)	(1.66)+	(0.35)	(1.91)+	(0.17)
Log illiterates	-1.372	0.494	0.36	4.34	-1.24	1.15	-0.1	0.863	-0.233
	(1.44)	(0.89)	(0.57)	(2.52)*	(1.18)	(1.57)	(0.32)	(1.69)+	(0.35)
Log crop area	-0.017	-0.014	0.031	-0.022	-0.041	0.05	-0.015	0.053	0.019
	(0.19)	(0.27)	(0.54)	(0.14)	(0.42)	(0.75)	(0.52)	(1.14)	(0.31)
lnTFP20	**0.185**	-0.017	0.016	0.087	-0.115	0	-0.003	0.01	-0.019
	(5.32)**	(1.04)	(0.89)	(2.44)*	(4.07)**	(0.01)	(0.35)	(0.58)	(1.03)
lnTFP21	-0.017	**0.143**	0.002	-0.054	-0.016	-0.015	0.002	0.019	-0.01
	(1.04)	**(8.90)****	(0.15)	(2.37)*	(0.91)	(0.95)	(0.25)	(1.45)	(0.71)
lnTFP22	0.016	0.002	**0.171**	0.06	0.041	0.02	-0.001	-0.039	-0.016
	(0.89)	(0.15)	**(8.94)****	(2.47)*	(2.08)*	(1.20)	(0.11)	(2.64)**	(1.03)
lnTFP23	0.087	-0.054	0.06	**0.394**	0.045	-0.02	-0.029	0.009	-0.034
	(2.44)*	(2.37)*	(2.47)*	**(5.17)****	(1.19)	(0.65)	(2.21)*	(0.37)	(1.29)
lnTFP24	-0.115	-0.016	0.041	0.045	**0.221**	0.085	-0.022	0.03	0.009
	(4.07)**	(0.91)	(2.08)*	(1.19)	**(5.55)****	(3.57)**	(1.98)*	(1.54)	(0.43)
lnTFP26	0	-0.015	0.02	-0.02	0.085	**0.164**	-0.019	0.003	0.003
	(0.01)	(0.95)	(1.20)	(0.65)	(3.57)**	**(5.41)****	(1.80)+	(0.18)	(0.14)
lnTFP27	-0.003	0.002	-0.001	-0.029	-0.022	-0.019	**0.019**	0.015	0
	(0.35)	(0.25)	(0.11)	(2.21)*	(1.98)*	(1.80)+	**(1.97)***	(1.55)	(0.05)
lnTFP28	0.01	0.019	-0.039	0.009	0.03	0.003	0.015	**0.181**	0.007
	(0.58)	(1.45)	(2.64)**	(0.37)	(1.54)	(0.18)	(1.55)	**(7.62)****	(0.46)
lnTFP29	-0.019	-0.01	-0.016	-0.034	0.009	0.003	0	0.007	**0.043**
	(1.03)	(0.71)	(1.03)	(1.29)	(0.43)	(0.14)	(0.05)	(0.46)	**(1.91)+**
lnTFP30	-0.065	0.032	-0.025	-0.171	-0.064	-0.102	0.034	0.038	0.031
	(1.50)	(1.20)	(0.89)	(2.36)*	(1.37)	(2.91)**	(2.31)*	(1.52)	(1.03)
lnTFP31	-0.041	-0.023	0.014	-0.21	-0.025	-0.012	-0.004	-0.027	-0.029
	(1.24)	(1.19)	(0.65)	(3.72)**	(0.68)	(0.47)	(0.38)	(1.50)	(1.26)
lnTFP32	0.002	0.011	-0.04	0.022	-0.006	0.028	0.013	0.01	0.047
	(0.10)	(0.73)	(2.46)*	(0.84)	(0.27)	(1.38)	(1.08)	(0.56)	(2.64)**
lnTFP33	0.021	0.027	-0.003	-0.061	0.008	0.034	0.003	0.04	0.005
	(0.76)	(1.45)	(0.18)	(1.46)	(0.25)	(1.37)	(0.24)	(2.14)*	(0.24)
lnTFP34	-0.019	0	0.008	-0.046	-0.006	-0.017	0.016	-0.023	0.017
	(1.21)	(0.03)	(0.55)	(2.24)*	(0.36)	(0.97)	(1.31)	(1.27)	(1.06)
lnTFP35	-0.026	0.032	-0.092	0.019	-0.037	0.006	0.018	0.04	0.074
	(0.93)	(1.53)	(3.81)**	(0.50)	(1.16)	(0.19)	(1.04)	(1.44)	(2.83)**
lnTFP36	0.046	0.052	-0.01	0.008	0.099	-0.055	0.014	0.039	0.056
	(1.29)	(2.04)*	(0.36)	(0.16)	(2.52)*	(1.56)	(0.85)	(1.32)	(1.88)+
lnTFP37	-0.06	-0.034	0.017	0.124	-0.122	-0.075	-0.025	-0.059	-0.057
	(1.25)	(1.14)	(0.52)	(1.69)+	(2.35)*	(1.87)+	(1.43)	(2.00)*	(1.66)+
lnTFP38	0.005	-0.01	-0.008	-0.009	-0.016	-0.019	0.001	0.007	-0.009
	(0.30)	(0.88)	(0.59)	(0.44)	(0.97)	(1.17)	(0.06)	(0.49)	(0.64)
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sum of endowment coefficients	0.3647	0.0382	0.9892	1.3506	1.3953	-1.9030	0.1275	0.0220	-0.5570
p-value	0.4665	0.8523	0.0001	0.1957	0.0103	0.0000	0.0003	0.9368	0.0169
R-squared	0.82	0.86	0.9	0.9	0.9	0.76	0.47	0.85	0.87
F test of TFP	6.73**	6.44**	8.41**	4.12**	6.41**	4.80**	1.64*	5.46**	2.27**
Observations	147	147	147	147	147	147	147	147	147

Absolute value of t statistics in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. Estimation method is SURE with linear homogeneity and cross-equation TFP constraints. The dependent variable shareXX refers to the share of industry XX in a state's GDP. The variable lnTFPXX refers to the Log of TFP of industry XX, where TFP is calculated as described in the text. Own TFP is in **bold**. The sum of endowment coefficients is the sum of coefficients on real fixed capital, literates, illiterates and crop area, if the regression is run without imposing the restriction that they sum to zero. The p-value is the p-value of the F-test that the sum of endowment coefficients is equal to zero, when the regression is run without imposing that restriction. The F test of TFP is a test of the joint significance of all the TFP terms. See the Data Appendix for details of the construction and sources of the variables.

Table 3.6: Regression equation (3.11) (factor endowments with technology differences) with cross-equation and homogeneity constraints

Dep. Var.	(10) share30	(11) share31	(12) share32	(13) share33	(14) share34	(15) share35	(16) share36	(17) share37	(18) share38
Log real fixed capital	2.336	0.721	0.173	1.216	-0.003	0.098	-0.063	-0.478	0.063
	(5.53)**	(1.60)	(2.00)*	(6.86)**	(0.05)	(0.76)	(0.37)	(1.39)	(0.87)
Log literates	-0.873	-4.235	0.281	0.354	-1.241	0.893	0.035	14.292	0.869
	(0.34)	(1.56)	(0.51)	(0.32)	(2.96)**	(1.10)	(0.03)	(6.65)**	(1.94)+
Log illiterates	-1.255	3.597	-0.431	-1.491	1.231	-1.039	0.199	-13.646	-0.872
	(0.45)	(1.21)	(0.73)	(1.26)	(2.70)**	(1.18)	(0.17)	(5.85)**	(1.80)+
Log crop area	-0.207	-0.083	-0.023	-0.079	0.013	0.048	-0.172	-0.167	-0.06
	(0.78)	(0.29)	(0.43)	(0.72)	(0.31)	(0.60)	(1.65)+	(0.78)	(1.37)
lnTFP20	-0.065	-0.041	0.002	0.021	-0.019	-0.026	0.046	-0.06	0.005
	(1.50)	(1.24)	(0.10)	(0.76)	(1.21)	(0.93)	(1.29)	(1.25)	(0.30)
lnTFP21	0.032	-0.023	0.011	0.027	0	0.032	0.052	-0.034	-0.01
	(1.20)	(1.19)	(0.73)	(1.45)	(0.03)	(1.53)	(2.04)*	(1.14)	(0.88)
lnTFP22	-0.025	0.014	-0.04	-0.003	0.008	-0.092	-0.01	0.017	-0.008
	(0.89)	(0.65)	(2.46)*	(0.18)	(0.55)	(3.81)**	(0.36)	(0.52)	(0.59)
lnTFP23	-0.171	-0.21	0.022	-0.061	-0.046	0.019	0.008	0.124	-0.009
	(2.36)*	(3.72)**	(0.84)	(1.46)	(2.24)*	(0.50)	(0.16)	(1.69)+	(0.44)
lnTFP24	-0.064	-0.025	-0.006	0.008	-0.006	-0.037	0.099	-0.122	-0.016
	(1.37)	(0.68)	(0.27)	(0.25)	(0.36)	(1.16)	(2.52)*	(2.35)*	(0.97)
lnTFP26	-0.102	-0.012	0.028	0.034	-0.017	0.006	-0.055	-0.075	-0.019
	(2.91)**	(0.47)	(1.38)	(1.37)	(0.97)	(0.19)	(1.56)	(1.87)+	(1.17)
lnTFP27	0.034	-0.004	0.013	0.003	0.016	0.018	0.014	-0.025	0.001
	(2.31)*	(0.38)	(1.08)	(0.24)	(1.31)	(1.04)	(0.85)	(1.43)	(0.06)
lnTFP28	0.038	-0.027	0.01	0.04	-0.023	0.04	0.039	-0.059	0.007
	(1.52)	(1.50)	(0.56)	(2.14)*	(1.27)	(1.44)	(1.32)	(2.00)*	(0.49)
lnTFP29	0.031	-0.029	0.047	0.005	0.017	0.074	0.056	-0.057	-0.009
	(1.03)	(1.26)	(2.64)**	(0.24)	(1.06)	(2.83)**	(1.88)+	(1.66)+	(0.64)
lnTFP30	**0.958**	0.443	0.082	0.158	0.039	-0.052	-0.067	-0.23	0.035
	(7.05)**	(5.20)**	(2.91)**	(3.05)**	(1.80)+	(1.24)	(1.22)	(2.41)*	(1.52)
lnTFP31	0.443	**1.202**	0.009	-0.037	0.001	0.027	0.015	0.03	0.008
	(5.20)**	**(11.16)****	(0.41)	(0.91)	(0.05)	(0.88)	(0.37)	(0.40)	(0.46)
lnTFP32	0.082	0.009	**0.262**	0.02	-0.016	0.019	0.046	-0.052	-0.019
	(2.91)**	(0.41)	**(8.86)****	(0.95)	(0.78)	(0.59)	(1.40)	(1.54)	(1.11)
lnTFP33	0.158	-0.037	0.02	**0.396**	0.001	0.033	0.084	-0.048	0.014
	(3.05)**	(0.91)	(0.95)	**(8.53)****	(0.05)	(1.06)	(2.11)*	(0.85)	(0.83)
lnTFP34	0.039	0.001	-0.016	0.001	**0.338**	-0.048	0.022	0.011	-0.029
	(1.80)+	(0.05)	(0.78)	(0.05)	**(10.51)****	(1.52)	(0.77)	(0.43)	(1.67)+
lnTFP35	-0.052	0.027	0.019	0.033	-0.048	**0.85**	0.005	-0.097	0.028
	(1.24)	(0.88)	(0.59)	(1.06)	(1.52)	**(12.92)****	(0.09)	(1.91)+	(1.14)
lnTFP36	-0.067	0.015	0.046	0.084	0.022	0.005	**0.677**	-0.011	-0.028
	(1.22)	(0.37)	(1.40)	(2.11)*	(0.77)	(0.09)	**(8.35)****	(0.17)	(1.09)
lnTFP37	-0.23	0.03	-0.052	-0.048	0.011	-0.097	-0.011	**0.424**	-0.035
	(2.41)*	(0.40)	(1.54)	(0.85)	(0.43)	(1.91)+	(0.17)	**(2.98)****	(1.32)
lnTFP38	0.035	0.008	-0.019	0.014	-0.029	0.028	-0.028	-0.035	**0.099**
	(1.52)	(0.46)	(1.11)	(0.83)	(1.67)+	(1.14)	(1.09)	(1.32)	**(5.17)****
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sum of endowment coefficients	0.7057	-4.0874	0.2457	3.8504	0.3690	0.1678	1.3845	3.3097	-0.6589
p-value	0.6886	0.0300	0.3832	0.0000	0.1372	0.7499	0.0478	0.0221	0.0000
R-squared	0.93	0.72	0.93	0.73	0.89	0.95	0.89	0.84	0.82
F test of TFP	6.31**	9.44**	6.78**	5.90**	7.65**	12.64**	5.74**	3.03**	2.56**
Observations	147	147	147	147	147	147	147	147	147

Absolute value of t statistics in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. Estimation method is SURE with linear homogeneity and cross-equation TFP constraints. The dependent variable shareXX refers to the share of industry XX in a state's GDP. The variable lnTFPXX refers to the Log of TFP of industry XX, where TFP is calculated as described in the text. Own TFP is in **bold**. The sum of endowment coefficients is the sum of coefficients on real fixed capital, literates, illiterates and crop area, if the regression is run without imposing the restriction that they sum to zero. The p-value is the p-value of the F-test that the sum of endowment coefficients is equal to zero, when the regression is run without imposing that restriction. The F test of TFP is a test of the joint significance of all the TFP terms. See the Data Appendix for details of the construction and sources of the variables.

Table 3.7: (continued from Table 3.6): Regression equation (3.11) (factor endowments with technology differences) with cross-equation and homogeneity constraints

resources between food products and man-made textiles. To take another example, the share of industry 31 (rubber and plastic) is, perhaps unsurprisingly, positively associated with productivity levels in industry 30 (chemical products), and negatively associated with productivity levels in industry 23 (cotton textiles), which may again suggest substitutability in the employment of factors of production between these two industries. Given the broad industry classifications used, such inferences are necessarily imprecise, but they are not incompatible with our priors about the relationship between industries.

We can test whether the TFP terms are jointly statistically significant. This amounts to testing the general neoclassical model outlined above, against the more restrictive Heckscher-Ohlin model which assumes identical technologies across all locations for each industry. If the Heckscher-Ohlin model is correct, the coefficients on TFP should be jointly statistically insignificant. We therefore perform an F-test for the joint significance of all the TFP terms. The results are in Tables 3.6 and 3.7. For all industries, the TFP terms are jointly significant at at least the 5 percent level. This result shows that technological differences across industries and locations have a statistically significant relationship with the share of an industry in a state.

For factor endowments, the results are similarly mixed. Of the four endowment variables, three of them (capital stock, literates and illiterates) have between 4 and 6 significant coefficients out of a possible 18. The amount of crop area is statistically significant in only one industry: industry 36 (machinery and equipment). Factor endowments have highly significant associations with industry share in industries 23 (cotton textiles), 30 (chemical products), 33 (basic metals), 34 (metal products) and 37 (transport equipment). At the other end of the spectrum, there are no significant factor endowment coefficients in industries 20 (food products), 21 (food products), 22 (beverages and tobacco), 24(man-made textiles), 27 (wood products), 29 (leather products), 31 (rubber and plastic) and 35 (machinery and equipment). Hence, once again there is some indication that factor endowments matter more in heavy industries, and less in food, textiles and light industries.

It is interesting to compare the results on the factor endowments between Table 3.6 and Table 3.7 with those of Table 3.5. We would expect there to be changes in the relationship between industry share and factor endowments when technology is included, if technology is correlated with factor endowments. We find that there are not many differences between the results with and without TFP. In Tables 3.6 and 3.7, when TFP is included, a total of 16 factor endowment coefficients are statistically significant, compared to 25 in Table 3.5 without TFP. Out of these, 13 of these coefficients are significant in both tables, and all of these 13 coefficients have the same sign. Therefore, we can conclude that TFP, while being very significantly associated with industry share, does not change the relationship between industry share and factor endowments.

In Tables 3.6 and 3.7, we also report the test of linear homogeneity of the revenue function. The null hypothesis that the sum of endowment coefficients is equal to zero, is rejected for 10 out of 18 industries at the 5 percent level. For industries 22 (beverages and tobacco), 24 (non-cotton textiles), 27 (wood products), 33 (basic metals), 36 (machinery and equipment) and 37 (transport equipment), the sum of coefficients is positive, suggesting increasing returns to scale, while for industries 26 (textile products), 29 (leather products), 31 (rubber and plastic) and 38 (other manufacturing), the sum of coefficients is negative, suggesting decreasing returns to scale. All the six industries which exhibited deviations from constant returns to scale without TFP in Table 3.5, also show the same deviations when TFP is included in Tables 3.6 and 3.7.

3.4.3 Robustness

The previous subsection has shown that factor endowments and technology are significantly related to the structure of industrial activity in India. However, as noted in section 3.2.1, the fact that the framework used is based on the assumption of perfectly competitive markets does raise some questions as to the interpretation and robustness of the results. This is especially the case in India, in which there are large distortions and state intervention in the economy. This subsection presents results which show that, while other factors such as politics and government policies, and market potential, are significantly related to the structure of Indian industry, factor endowments and technology continue to matter even when these additional factors are taken into account. The inclusion of the controls does not substantially change the pattern of estimation results.

We therefore run regression equation (3.11) with TFP, augmented to include several robustness controls. First, we include a set of variables to control for the political history of the state, to capture potential political influences on industrial activity, for instance, unobserved state-level policies that change over time. India is the world's largest democracy, and the diversity of interests among the population, in terms of ethnic groups, religion, and caste, has given rise to a large number of political parties. For instance, in the 1989 general election, there were 8 national parties and 20 state parties. No party in India has survived the last 50-odd years since Independence without splits or amalgamations. We therefore amalgamate the various parties into five broad groupings: the Janata parties, the Hindu parties, the Hard Left parties, the Congress party, and regional parties (details in the Appendix to this chapter). The measure we use is a measure for the number of years a Janata, Hindu, Hard Left, regional, or the Congress party has been in power in a state. There is a potential concern over the endogeneity of political histories, which may be influenced by economic performance. However, we believe that this is more important at the aggregate level, rather than at the industry level which we analyse here, where the political impact of success or failure of any one industry may be counteracted by opposite outcomes in other industries.

We also include a measure of labour regulation taken from Besley and Burgess (2004), which measures the extent to which labour regulation in a given state is pro-labour or pro-capital. This measure is based on amendments to the Industrial Disputes Act of 1947. Industrial relations law is on the concurrent list under the Indian Constitution. This means that it can be modified by both central and state governments. These amendments are listed in Malik (1997). Besley and Burgess read the text of the state-level amendments, and code them as either pro-labour (+1) or pro-capital (-1) amendments. This is a measure of the net direction of change in any one year, so for example if there are 4 pro-labour amendments in one year, this is coded as +1. They then cumulate these changes over time to form a measure of the state's policy stance towards labour. By including this variable in the regression, we want to capture the possible effects that pro-capital or pro-labour policies may have on the shares of different industries.

Two measures of market potential are used to capture the effects of proximity to centres of economic activity. The idea here is that, all else equal, industries prefer to locate in places where more economic activity takes place, to benefit from closer proximity to markets and suppliers. But in equilibrium, all else is not equal; prices of immobile factors adjust so that some activities locate in central locations and others locate in more remote locations. We capture this idea of proximity to markets by constructing measures of domestic and foreign market access. Domestic market access is measured following Harris (1954) as distance-weighted SDP in all 16 major states within India:

$$DMA_{zt} = \sum_{z=1}^{Z} \frac{SDP_{zt}}{d_{yz}} \tag{3.15}$$

where d_{yz} is the bilateral distance between the capitals of states y and z. Foreign market access is similarly defined to be distance-weighted size of ports:

$$FMA_{zt} = \sum_{p=1}^{P} \frac{TRADE_{pt}}{d_{pz}} \tag{3.16}$$

where the summation is over all major ports in the country, and $TRADE_{pt}$ is the total trade volume of the port. The distance between any two states or between a state and a port, is the road distance between state capitals, or between the state capital and the port. The distance between a state and itself is set at the average distance between a state and itself, given by the formula $\frac{2}{3}\left(\frac{area}{\pi}\right)^{\frac{1}{2}}$; the same is true when the state capital is itself a major port.[28] In calculating values for DMA_{zt}, we include Delhi in the summation, since it is a Union Territory that has a large SDP.[29]

Tables 3.8 and 3.9 present the results. All our robustness measures are related to industry shares to a greater or lesser extent. One noteworthy aspect is that, for any given industry, the political histories tend to have the same coefficient sign, which suggests that all the political parties have preferences for the same industries. Political history can impact on the size of registered manufacturing as a whole relative to other industries. However, it is possible that political histories could have different effects in the non-manufacturing industries not included here. Another point is that, when both domestic and foreign market potential are significant, they always have the same coefficient signs. This provides evidence that industries which are more sensitive to proximity to markets have increased sensitivity to both domestic and foreign markets.

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28 See Overman, Redding and Venables (2003) for a discussion of different measures of market access.

29 There is a potential econometric concern in using domestic market access in the regression, as shocks that affect the share of an industry in a state would also affect SDP and hence domestic market access. We explored using lagged values of domestic and foreign market access as instruments for domestic market access. An F-test of the significance of the excluded variables in the first stage regression is highly significant at better than 1 percent, and the instruments also pass the Sargan-Hansen test for overidentification. These results show that the instruments are highly correlated with the instrumented variable, and are jointly valid. Further, a Hausman (1978) test of the null hypothesis that the coefficients do not differ systematically between IV and OLS, cannot be rejected for any industry at any conventional significance level. This suggests that biases due to endogeneity problems are not severe. As an additional robustness check, we excluded own SDP when calculating domestic market potential, and ran the regression with this alternative measure. The results were almost identical to the ones reported in the text.

Dep. Var.	(1) share20	(2) share21	(3) share22	(4) share23	(5) share24	(6) share26	(7) share27	(8) share28	(9) share29
Log real fixed capital	-0.005	-0.154	-0.01	-0.384	-0.052	-0.232	0.014	-0.104	0.021
	(0.03)	(1.94)+	(0.11)	(1.67)+	(0.32)	(2.40)*	(0.40)	(1.30)	(0.28)
Log literates	0.876	0.142	-0.448	0.814	0.203	-0.95	0.076	-0.245	0.767
	(0.83)	(0.24)	(0.71)	(0.49)	(0.17)	(1.32)	(0.30)	(0.41)	(1.42)
Log illiterates	-0.892	0.023	0.403	-0.507	-0.175	1.2	-0.076	0.319	-0.792
	(0.81)	(0.04)	(0.61)	(0.29)	(0.14)	(1.60)	(0.29)	(0.52)	(1.40)
Log crop area	0.021	-0.011	0.055	0.077	0.024	-0.018	-0.014	0.03	0.004
	(0.24)	(0.23)	(1.06)	(0.55)	(0.24)	(0.31)	(0.68)	(0.62)	(0.09)
Own TFP	0.178	0.141	0.165	0.301	0.256	0.127	0.02	0.192	0.028
	(5.17)**	(9.31)**	(8.26)**	(4.45)**	(5.84)**	(4.67)**	(2.46)*	(7.81)**	(1.51)
Janata majority	0.039	0.021	0.093	-0.013	0.044	-0.007	-0.001	0.059	0.004
	(1.22)	(1.17)	(4.80)**	(0.25)	(1.22)	(0.34)	(0.11)	(3.29)**	(0.23)
Hindu majority	0.12	0.023	0.065	0.038	0.101	-0.089	-0.001	0.064	0.013
	(2.38)*	(0.84)	(2.15)*	(0.47)	(1.79)+	(2.64)**	(0.07)	(2.29)*	(0.49)
Hard left majority	0.018	0.012	0.096	0.065	-0.006	-0.059	0	0.04	-0.012
	(0.57)	(0.71)	(5.04)**	(1.27)	(0.16)	(2.73)**	(0.03)	(2.25)*	(0.73)
Regional majority	0.042	0.03	0.096	0.101	0.057	-0.008	-0.002	0.048	0.01
	(1.29)	(1.69)+	(4.88)**	(1.96)*	(1.55)	(0.39)	(0.20)	(2.67)**	(0.61)
Congress majority	0.037	0.021	0.093	-0.032	0.031	-0.028	-0.005	0.038	-0.011
	(1.32)	(1.34)	(5.56)**	(0.70)	(0.98)	(1.46)	(0.68)	(2.47)*	(0.75)
Labour regulation	0.02	0.005	-0.017	-0.177	0.039	-0.044	0.012	-0.029	-0.014
	(0.36)	(0.17)	(0.49)	(2.00)*	(0.63)	(1.15)	(0.91)	(0.93)	(0.48)
Foreign market	-1.234	0.116	-2.411	-1.435	-2.329	3.176	-0.117	-0.243	1.072
potential	(0.99)	(0.17)	(3.28)**	(0.73)	(1.68)+	(3.79)**	(0.40)	(0.36)	(1.71)+
Domestic market	-0.162	-0.382	-0.998	0.772	-0.277	0.561	0.034	-0.722	-0.077
potential	(0.34)	(1.44)	(3.41)**	(1.02)	(0.51)	(1.72)+	(0.28)	(2.64)**	(0.30)
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sum of endowment coefficients	-0.8851	0.4380	0.9037	5.7187	1.3710	-1.1803	0.1796	-0.5567	-0.3501
p-value	0.1927	0.1093	0.0069	0.0000	0.0502	0.0127	0.0001	0.1178	0.2355
R-squared	0.83	0.88	0.92	0.93	0.92	0.84	0.75	0.87	0.91
F test of TFP	7.32**	6.62**	7.53**	3.20**	5.76**	3.29**	1.4	5.74**	2.07
Observations	147	147	147	147	147	147	147	147	147

Absolute value of t statistics in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. Estimation method is SURE with linear homogeneity and cross-equation TFP constraints. The dependent variable shareXX refers to the share of industry XX in a state's GDP. Own TFP refers to the log of TFP in that industry; cross-industry TFP is included in the regression but not reported. Janata, Hindu, Hard Left, Regional and Congress majority are variables measuring the number of years these political groupings have had a majority in the state assembly. Foreign and domestic market potential are distance-weighted international trade of major ports and State Domestic Product respectively.
The sum of endowment coefficients is the sum of coefficients on real fixed capital, literates, illiterates and crop area, if the regression is run without imposing the restriction that they sum to zero. The p-value is the p-value of the F-test that the sum of endowment coefficients is equal to zero, when the regression is run without imposing that restriction.
The F test of TFP is a test of the joint significance of all the TFP terms. See the Data Appendix for details of the construction and sources of the variables.

Table 3.8: Robustness checks on regression equation (3.11) (factor endowments with technology differences) with cross-equation and homogeneity constraints

	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Dep. Var.	share30	share31	share32	share33	share34	share35	share36	share37	share38
Log real fixed capital	2.063	0.395	0.051	0.953	-0.056	0.039	-0.163	-0.097	0.028
	(5.04)**	(0.85)	(0.63)	(5.91)**	(0.78)	(0.29)	(1.02)	(0.34)	(0.41)
Log literates	-6.896	-2.132	-0.029	-2.02	-1.689	0.707	-1.747	4.139	0.767
	(2.34)*	(0.63)	(0.05)	(1.69)+	(3.23)**	(0.71)	(1.48)	(1.99)*	(1.49)
Log illiterates	5.012	1.804	0.073	1.085	1.75	-0.702	2.149	-3.715	-0.707
	(1.61)	(0.51)	(0.12)	(0.87)	(3.19)**	(0.68)	(1.75)+	(1.70)+	(1.32)
Log crop area	-0.179	-0.067	-0.095	-0.018	-0.005	-0.044	-0.239	-0.327	-0.088
	(0.71)	(0.23)	(1.96)*	(0.19)	(0.12)	(0.55)	(2.52)*	(1.91)+	(2.15)*
Own TFP	0.873	1.305	0.277	0.342	0.318	0.893	0.6	0.437	0.088
	(6.71)**	(11.70)**	(10.00)**	(7.44)**	(9.57)**	(13.35)**	(8.18)**	(4.01)**	(4.25)**
Janata majority	-0.09	-0.027	0.058	0.083	0.029	0.028	0.003	-0.141	-0.045
	(1.00)	(0.27)	(3.17)**	(2.37)*	(1.82)+	(0.92)	(0.09)	(2.28)*	(2.82)**
Hindu majority	0.441	0.174	-0.047	0.095	0.005	-0.068	0.117	-0.331	-0.076
	(3.04)**	(1.07)	(1.65)+	(1.69)+	(0.20)	(1.45)	(2.10)*	(3.34)**	(3.10)**
Hard left majority	-0.187	-0.14	0.016	0.005	0.024	-0.01	-0.03	-0.298	-0.053
	(2.05)*	(1.37)	(0.87)	(0.13)	(1.51)	(0.35)	(0.85)	(4.78)**	(3.40)**
Regional majority	-0.211	-0.026	0.027	0.064	0.024	-0.001	-0.048	-0.304	-0.047
	(2.28)*	(0.25)	(1.49)	(1.79)+	(1.49)	(0.03)	(1.33)	(4.79)**	(3.00)**
Congress majority	-0.048	-0.064	0.022	0.078	0.033	-0.021	-0.016	-0.302	-0.042
	(0.60)	(0.70)	(1.40)	(2.51)*	(2.39)*	(0.80)	(0.53)	(5.48)**	(3.10)**
Labour regulation	0.079	0.291	-0.02	0.122	-0.034	-0.071	-0.18	-0.157	0.002
	(0.50)	(1.65)+	(0.60)	(1.93)+	(1.21)	(1.34)	(2.84)**	(1.45)	(0.07)
Foreign market	3.581	6.594	-0.006	-3.882	-0.925	0.303	-0.232	-0.707	1.278
potential	(1.00)	(1.65)+	(0.01)	(2.83)**	(1.54)	(0.26)	(0.17)	(0.29)	(2.17)*
Domestic market	0.832	0.791	-0.684	-1.423	-0.391	0.027	0.143	6.081	0.453
potential	(0.62)	(0.53)	(2.47)*	(2.66)**	(1.60)	(0.06)	(0.27)	(6.57)**	(1.89)+
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sum of endowment									
coefficients	-7.7866	-5.6257	0.4367	3.9323	0.2622	1.0505	-0.7362	3.8520	-0.5304
p-value	0.0006	0.0317	0.2053	0.0000	0.4278	0.1361	0.3949	0.0115	0.0072
R-squared	0.95	0.74	0.95	0.82	0.9	0.96	0.92	0.91	0.86
F test of TFP	5.14**	10.51**	8.01**	4.31**	6.46**	14.01**	5.31**	4.25**	1.73*
Observations	147	147	147	147	147	147	147	147	147

Absolute value of t statistics in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. Estimation method is SURE with linear homogeneity and cross-equation TFP constraints. The dependent variable shareXX refers to the share of industry XX in a state's GDP. Own TFP refers to the log of TFP in that industry; cross-industry TFP is included in the regression but not reported. Janata, Hindu, Hard Left, Regional and Congress majority are variables measuring the number of years these political groupings have had a majority in the state assembly. Foreign and domestic market potential are distance-weighted international trade of major ports and State Domestic Product respectively. The sum of endowment coefficients is the sum of coefficients on real fixed capital, literates, illiterates and crop area, if the regression is run without imposing the restriction that they sum to zero. The p-value is the p-value of the F-test that the sum of endowment coefficients is equal to zero, when the regression is run without imposing that restriction. The F test of TFP is a test of the joint significance of all the TFP terms. See the Data Appendix for details of the construction and sources of the variables.

Table 3.9: (continued from Table 3.8): Robustness checks on regression equation (3.11) (factor endowments with technology differences) with cross-equation and homogeneity constraints

After controlling for these other factors, own TFP remains significantly positively associated with industry share in 17 of our 18 industries. Factor endowments tend to have fewer significant coefficients which may be attributed to increasing multicollinearity and loss of degrees of freedom as more control variables are included in the regression. Nevertheless the results mirror those of Tables 3.6 and 3.7 fairly closely. Factor endowments have particularly significant associations with industry share in industries 30 (chemical products), 33 (basic metals), 34 (metal products) and 37 (transport equipment). Each factor endowment has between 3 and 5 significant coefficients. In industries 20 (food products), 22 (beverages and tobacco), 24 (man-made textiles), 27 (wood products), 28 (paper products), 29 (leather products), 31 (rubber and plastic) and 35 (machinery and equipment), factor endowments are not significantly related to industry shares when political histories and market access are taken into account. Once again there is evidence that factor endowments matter more for heavy industries than for textile and other light industries.

In Tables 3.8 and 3.9, we also report the results of the test of linear homogeneity. The null hypothesis that the sum of endowment coefficients is equal to zero, is rejected at the 5 percent level for 9 industries. In industries 22 (beverages and tobacco), 23 (cotton textiles), 27 (wood products), 33 (basic metals) and 37 (transport equipment), the sum of coefficients is positive, indicating increasing returns, while in industries 26 (textile products), 30 (chemical products), 31 (rubber and plastic) and 38 (other manufacturing), the sum of coefficients is negative, indicating decreasing returns. This result is again similar to that in Tables 3.6 and 3.7. Therefore, introducing political and market access variables as robustness checks on the association between factor endowments and technology, and industry shares, while reducing the statistical significance of these variables, does not fundamentally alter the relationship between them.

Comparing the results on linear homogeneity across tables, we can conclude that there is mixed evidence on the presence of constant returns to scale in the production technology across Indian industries. Across the different specifications, industries 22 (beverages and tobacco), 27 (wood products) and 33 (basic metals) consistently exhibit increasing returns to scale, while industries 26 (textile products) and 38 (other manufacturing) consistently exhibit decreasing returns to scale. On the other hand, in industries 20 (food products), 21 (food products), 28 (paper products), 32 (non-metallic mineral

	(1) share20	(2) share21	(3) share22	(4) share23	(5) share24	(6) share26	(7) share27	(8) share28	(9) share29
Log real fixed capital	-0.008	-0.559+	-0.024	-0.239+	-0.062	-0.600*	0.353	-0.328	0.066
Log literates	1.439	0.48	-1.034	0.47	0.225	-2.283	1.804	-0.717	2.25
Log illiterates	-1.568	0.082	0.995	-0.313	-0.208	3.087	-1.932	1.001	-2.487
Log crop area	0.028	-0.031	0.102	0.036	0.021	-0.035	-0.265	0.071	0.009
lnTFP20	0.326**	-0.053	0.008	0.072**	-0.124**	0.097+	-0.273	-0.014	-0.05
lnTFP21	-0.021	0.435**	-0.025	-0.018	-0.018	-0.029	0.049	0.028	-0.044
lnTFP22	0.004	-0.029	0.281**	0.018+	0.009	0.006	-0.09	-0.103**	-0.088**
lnTFP23	0.132**	-0.082	0.072+	0.124**	0.072*	-0.067	-0.300+	-0.094+	-0.035
lnTFP24	-0.112**	-0.04	0.018	0.036*	0.192**	0.139**	-0.415**	-0.05	0.003
lnTFP26	0.046+	-0.034	0.006	-0.017	0.073**	0.235**	-0.073	-0.028	0.019
lnTFP27	-0.012	0.006	-0.009	-0.008+	-0.021**	-0.007	0.355*	0.032+	0.005
lnTFP28	-0.007	0.033	-0.105**	-0.025+	-0.027	-0.028	0.330+	0.535**	0
lnTFP29	-0.024	-0.053	-0.089**	-0.009	0.002	0.019	0.051	0	0.077
lnTFP30	-0.101+	0.044	-0.024	-0.041	-0.042	-0.102	0.054	0.09	-0.005
lnTFP31	-0.043	-0.028	0.018	-0.049+	-0.007	0.016	0.019	-0.054	0.002
lnTFP32	-0.002	0.01	-0.093**	-0.007	-0.052**	0.035	0.236	0.051	0.082*
lnTFP33	-0.005	0.022	-0.047	-0.025	-0.026	-0.005	0.145	0.031	-0.062
lnTFP34	-0.021	-0.01	0.008	-0.013*	-0.011	-0.026	0.128	-0.02	0.006
lnTFP35	-0.022	0.04	-0.115**	-0.005	-0.038*	-0.004	0.136	0.063+	0.086**
lnTFP36	0.016	0.048	-0.008	0	0.029	-0.076+	-0.013	0.062	0.041
lnTFP37	-0.078	-0.073	0.035	0.017	-0.079	-0.102	-0.456+	-0.274**	-0.063
lnTFP38	0.01	-0.015	0.001	-0.006	-0.014	-0.032	0.077	0.031	0.018
Janata majority	0.385	0.419	1.293**	-0.044	0.294	-0.108	-0.119	1.038**	0.068
Hindu majority	0.134*	0.054	0.102*	0.015	0.076+	-0.146**	-0.015	0.128*	0.025
Hard left majority	0.196	0.272	1.446**	0.243	-0.042	-0.921**	-0.032	0.760*	-0.227
Regional majority	0.907	1.343+	2.910**	0.771*	0.828	-0.268	-0.496	1.862**	0.394
Congress majority	0.648	0.743	2.284**	-0.194	0.364	-0.706	-1.155	1.194*	-0.337
Labour regulation	0.082	0.044	-0.096	-0.256*	0.11	-0.264	0.738	-0.214	-0.102
Foreign market potential	-0.249	0.048	-0.683**	-0.102	-0.317+	0.938**	-0.339	-0.087	0.386+
Domestic market potential	-0.19	-0.92	-1.643**	0.318	-0.22	0.963+	0.57	-1.509**	-0.161
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	147	147	147	147	147	147	147	147	147
R-squared	0.83	0.88	0.92	0.93	0.92	0.84	0.75	0.87	0.91

Notes: + significant at 10% * significant at 5% ** significant at 1%. Normalised beta coefficients reported. Beta coefficients are constructed by taking the regression coefficients, multiplying by the standard deviation of the explanatory variable, and dividing by the standard deviation of the dependent variable. A beta coefficient of 0.5 for example means that a one standard deviation increase in the explanatory variable will increase the dependent variable by 0.5 standard deviations. Estimation method is SURE with linear homogeneity and cross-equation TFP constraints. The dependent variable shareXX refers to the share of industry XX in a state's GDP. The variable lnTFPXX refers to the log of TFP of industry XX, where TFP is calculated as described in the text. See the Data Appendix for details of the construction and sources of the variables.

Table 3.10: Standardised beta coefficients for regression equation (3.11) with robustness controls.

	(10) share30	(11) share31	(12) share32	(13) share33	(14) share34	(15) share35	(16) share36	(17) share37	(18) share38
Log real fixed capital	0.596**	0.23	0.098	1.462**	-0.165	0.036	-0.171	-0.056	0.154
Log literates	-1.851*	-1.155	-0.052	-2.880+	-4.606**	0.602	-1.706	2.227*	3.878
Log illiterates	1.44	1.046	0.138	1.657	5.111**	-0.64	2.247+	-2.140+	-3.827
Log crop area	-0.039	-0.029	-0.136*	-0.021	-0.011	-0.031	-0.189*	-0.143+	-0.363*
lnTFP20	-0.022+	-0.019	-0.004	-0.005	-0.08	-0.029	0.019	-0.032	0.045
lnTFP21	0.004	-0.005	0.007	0.01	-0.015	0.021	0.023	-0.012	-0.028
lnTFP22	-0.002	0.004	-0.076**	-0.024	0.013	-0.073**	-0.004	0.007	0.002
lnTFP23	-0.016	-0.038+	-0.023	-0.05	-0.089*	-0.013	-0.001	0.013	-0.055
lnTFP24	-0.008	-0.003	-0.081**	-0.025	-0.037	-0.046*	0.031	-0.029	-0.06
lnTFP26	-0.01	0.003	0.029	-0.002	-0.046	-0.002	-0.044+	-0.02	-0.072
lnTFP27	0.001	0	0.019	0.007	0.022	0.008	-0.001	-0.008+	0.017
lnTFP28	0.009	-0.011	0.042	0.016	-0.036	0.040+	0.036	-0.053**	0.071
lnTFP29	0	0	0.068*	-0.032	0.011	0.055**	0.024	-0.012	0.04
lnTFP30	0.198**	0.143**	0.118**	0.122*	0.103+	-0.024	-0.06	-0.048	0.092
lnTFP31	0.072**	0.602**	0.006	-0.077	-0.023	0.03	-0.025	-0.042	0.043
lnTFP32	0.015**	0.001	0.338**	-0.008	-0.031	0.018	0.028	-0.022+	0.036
lnTFP33	0.024*	-0.03	-0.013	0.433**	-0.071	-0.006	0.015	-0.017	0.062
lnTFP34	0.006+	-0.003	-0.014	-0.021	0.433**	-0.024+	0.009	0.007	-0.100*
lnTFP35	-0.004	0.01	0.023	-0.005	-0.067+	0.327**	-0.005	-0.023*	0.061
lnTFP36	-0.011	-0.009	0.041	0.013	0.026	-0.005	0.320**	0.001	-0.107
lnTFP37	-0.026	-0.044	-0.092+	-0.045	0.066	-0.077*	0.002	0.211**	-0.186
lnTFP38	0.004	0.004	0.013	0.014	-0.078*	0.017	-0.027	-0.016	0.324**
Janata majority	-0.146	-0.09	0.617**	0.719*	0.477+	0.142	0.019	-0.459*	-1.369**
Hindu majority	0.081**	0.064	-0.057+	0.092+	0.009	-0.039	0.077*	-0.121**	-0.260**
Hard left majority	-0.327*	-0.494	0.18	0.042	0.417	-0.058	-0.19	-1.044**	-1.732**
Regional majority	-0.744*	-0.188	0.637	1.206+	0.852	-0.01	-0.614	-2.151**	-3.155**
Congress majority	-0.137	-0.365	0.417	1.184*	0.955*	-0.19	-0.17	-1.723**	-2.259**
Labour regulation	0.053	0.395+	-0.087	0.435+	-0.231	-0.152	-0.440**	-0.212	0.024
Foreign market potential	0.118	0.439+	-0.001	-0.680**	-0.31	0.032	-0.028	-0.047	0.793*
Domestic market potential	0.159	0.306	-0.863*	-1.448**	-0.763	0.017	0.1	2.336**	1.636+
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	147	147	147	147	147	147	147	147	147
R-squared	0.95	0.74	0.95	0.82	0.9	0.96	0.92	0.91	0.86

Notes: + significant at 10% * significant at 5% ** significant at 1%. Normalised beta coefficients reported. Beta coefficients are constructed by taking the regression coefficients, multiplying by the standard deviation of the explanatory variable, and dividing by the standard deviation of the dependent variable. A beta coefficient of 0.5 for example means that a one standard deviation increase in the explanatory variable will increase the dependent variable by 0.5 standard deviations. Estimation method is SURE with linear homogeneity and cross-equation TFP constraints. The dependent variable shareXX refers to the share of industry XX in a state's GDP. The variable lnTFPXX refers to the log of TFP of industry XX, where TFP is calculated as described in the text. See the Data Appendix for details of the construction and sources of the variables.

Table 3.11: (continued from Table 3.10): Standardised beta coefficients for regression equation (3.11) with robustness controls

products), 34 (metal products) and 35 (machinery and equipment), we never reject the null hypothesis in any specification, thus giving strong evidence of constant returns to scale in these industries.

The finding that factor endowments, technology and politics are statistically significantly associated with industry share is important, but one would also like to know the economic importance of these variables. To address this issue, we report in Tables 3.10 and 3.11 the standardised beta coefficients of the regression in Tables 3.8 and 3.9. Beta coefficients are constructed by multiplying the regression coefficients by the standard deviation of the explanatory variable, and dividing by the standard deviation of the dependent variable. A beta coefficient of 0.5, for example, means that a one standard deviation increase in the explanatory variable, increases the dependent variable by 0.5 standard deviations.

From Tables 3.10 and 3.11, we see that, for the endowment variables, when capital stock and crop area are statistically significant, they have moderate to large associations with industry share, with absolute beta coefficients in the region of 0.13 to 1.46. In contrast, endowments of literates and illiterates have much larger associations, with absolute beta coefficients ranging from 1.8 to 5.1 when they are statistically significant. Own TFP tends to have moderate effects, with absolute beta coefficients of between 0.12 and 0.6 when it is statistically significant, while cross TFP effects are much weaker, with beta coefficients between 0.01 and 0.27 when it is statistically significant.

Political variables show much more variation in economic importance. When statistically significant, political history has beta coefficients ranging from 0.05 to 3.1. The number of years under a Hindu party has the smallest association with industry share, while the number of years under a regional party has the largest association, among the political groupings considered. Labour regulation, measuring the policy stance of a state towards labour, has moderate effects, with beta coefficient of between 0.25 and 0.44 when statistically significant. Finally, measures of market access, while not frequently statistically significant, have large associations with industry share (beta coefficients of between 0.31 and 2.3) when they are statistically significant. Domestic market potential tends to have larger effects than foreign market potential.

3.4.4 Testing for Structural Breaks

Another specification test performed is to test for structural breaks in the data. There are two candidates for the time of the structural break - the reform initiated by Rajiv Gandhi in 1985, and the more general reform begun in 1991.

We perform the tests for both specifications, with and without TFP. As in the previous section, to facilitate comparisons, we focus on a consistent sample of observations across all specifications, so we have 147 observations in each regression. To test for the presence of a structural break in 1985 against the null hypothesis of no structural breaks, we augment the estimated equations (3.10) and (3.11) with a set of terms interacting the RHS variables with a reform dummy. That is, we run the following regressions:

$$\begin{aligned} S_{zjt} &= \beta_{0j} + \eta_{zj} + d_{jt} + \delta_{zj}\left[R \times \eta_{zj}\right] + \textstyle\sum_i \gamma_{ji} \ln(v_{zit}) \\ &\quad + \textstyle\sum_i \phi_{ji}\left[R \times \ln(v_{zit})\right] + \omega_{zjt} \end{aligned} \tag{3.17}$$

$$\begin{aligned} S_{zjt} &= \beta_{0j} + \eta_{zj} + d_{jt} + \delta_{zj}\left[R \times \eta_{zj}\right] + \textstyle\sum_j \beta_{jk} \ln(\theta_{zjt}) \\ &\quad + \textstyle\sum_i \gamma_{ji} \ln(v_{zit}) + \textstyle\sum_j \varphi_{jk}\left[R \times \ln(\theta_{zjt})\right] \\ &\quad + \textstyle\sum_i \phi_{ji}\left[R \times \ln(v_{zit})\right] + \omega_{zjt} \end{aligned} \tag{3.18}$$

where R is an indicator variable taking value 0 if the observation is from 1985 or before (pre-reform), and taking value 1 if the observation is from after 1985 (post-reform). Therefore, the coefficients on the interaction terms may be interpreted as the additional impact of that variable in the period after reform. An F-test of the joint significance of the coefficients δ_{zj} and ϕ_{ji} in equation (3.17), and an F-test of the joint significance of δ_{zj}, ϕ_{ji} and φ_{jk} in equation (3.18), is a test of whether the coefficients on all variables (factor endowments, technology, state dummies) differ before and after 1985. This is equivalent to a Chow (1960) test for structural breaks.[30]

The same test is performed using 1991 as the year of the structural break, and for the test that there are two structural breaks (1985 and 1991), where we have two sets of interaction terms, one for each possible break time. When considering two structural

[30] This assumes that the impact of the liberalisation on the relationship between industry share, factor endowment and, technology, is instantaneous. More realistically, the liberalisation should affect this relationship with a lag. This lagged response is being explored in ongoing research.

	Break in 1991				Break in 1985			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TFP	No	No	Yes	Yes	No	No	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Industry	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat
20	4.28**	5.33**	3.99**	5.87**	1.90*	1.17	3.71**	3.12**
21	1.96*	1.55	1.17	1.88*	1.66	1.23	0.63	0.91
22	5.99**	4.20**	2.68**	3.97**	2.83**	1.69	1.74*	1.20
23	6.38**	5.50**	4.40**	4.05**	23.16**	11.10**	10.70**	9.58**
24	4.54**	4.47**	5.83**	5.67**	6.15**	5.03**	5.84**	4.59**
26	16.56**	12.49**	9.94**	8.91**	5.05**	1.99*	2.23**	2.03*
27	6.99**	2.16**	0.69	0.65	3.63**	7.73**	0.30	0.53
28	3.00**	2.40**	2.61**	2.72**	2.68**	2.72**	1.59	2.37**
29	14.93**	12.02**	3.41**	4.73**	4.78**	2.72**	2.46**	1.49
30	15.47**	11.33**	9.50**	9.11**	10.80**	5.72**	7.13**	6.63**
31	4.03**	2.60**	3.78**	4.02**	4.61**	3.05**	3.75**	3.30**
32	4.22**	5.05**	3.01**	3.17**	2.61**	3.02**	2.43**	2.74**
33	3.19**	4.76**	3.40**	3.16**	9.46**	3.80**	5.33**	3.47**
34	2.20*	2.41**	4.02**	5.24**	3.00**	3.26**	1.79*	1.75*
35	1.84	3.90**	3.93**	3.99**	3.90**	3.00**	3.52**	3.56**
36	3.65**	1.32	3.35**	2.87**	7.11**	4.49**	5.09**	4.68**
37	14.37**	7.12**	9.53**	9.28**	5.48**	3.67**	4.34**	4.18**
38	10.64**	7.17**	2.61**	2.71**	2.23*	2.34**	1.44	1.06

Notes: * significant at 5% ** significant at 1%. The table reports the F-statistic for the test that the interaction terms of all RHS variables are jointly insignificant. Each column reports the test for a different specification. TFP refers to whether or not the specification includes TFP and its interaction terms, and Controls refers to whether or not the specification includes political and market access controls and their interaction terms. The critical values at the 5 and 1 percent levels of the F statistic are:
Columns (1) and (5): $F(11, 91)=1.87, 2.42$. Columns (2) and (6): $F(18, 75)=1.73, 2.16$.
Columns (3) and (7): $F(29, 55)=1.67, 2.07$. Columns (4) and (8): $F(37, 39)=1.70, 2.13$.

Table 3.12: Test of structural breaks in 1985 and 1991.

breaks, we can test for the alternative hypothesis of the presence of two structural breaks, against different null hypotheses of no breaks, or a single break in 1985 or 1991.

Table 3.12 reports the results of these tests for a single structural break in either 1991 or 1985, against the null hypothesis of no structural breaks. There is strong evidence of a structural break in 1991 for all industries. The only exception is industry 27 (wood products), when we include TFP in the specification. There is also evidence of structural breaks in many industries in 1985, except that the null hypothesis of no structural breaks is rejected for fewer industries (between 13 and 17 out of 18 industries, depending on the specification).[31] Industry 21 (food products) in particular shows no evidence of a structural break in 1985 under any specification.

[31] We also find evidence of a structural break in 1985 for the majority of industries across all specifications if we limit the sample period to 1980-1990.

	Break in both 1985 and 1991 (test of 2 breaks against no break)			Test structural break in 1985 (assuming break in 1991)			Test structural break in 1991 (assuming break in 1985)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
TFP	No	No	Yes	No	No	Yes	No	No	Yes
Controls	No	Yes	No	No	Yes	No	No	Yes	No
Industry	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat
20	2.65**	3.49**	4.27**	0.78	1.17	2.35*	2.98**	5.11**	1.95
21	1.73*	1.93*	0.97	1.30	1.77	0.80	1.59	2.30*	1.14
22	3.94**	3.51**	2.46*	1.27	0.52	1.57	4.09**	3.20**	2.05
23	16.96**	8.90**	10.04**	18.10**	9.96**	8.89**	3.73**	3.31**	3.67**
24	5.33**	6.98**	6.81**	4.47**	5.80**	4.01**	3.02**	5.36**	5.29**
26	10.07**	7.25**	9.35**	1.52	0.93	2.57*	10.68**	10.26**	12.24**
27	4.94**	5.80**	0.79	1.84	6.86**	0.45	4.82**	1.75	1.03
28	3.52**	3.15**	2.84**	3.26**	3.03**	1.87	3.57**	2.82**	3.10**
29	12.43**	9.75**	3.46**	4.49**	2.92**	1.70	14.46**	12.51**	3.51**
30	16.70**	14.89**	11.61**	7.87**	6.07**	6.43**	12.10**	11.71**	9.16**
31	3.63**	2.63**	6.12**	2.40*	2.13*	6.13**	1.96*	1.99*	6.29**
32	4.19**	5.16**	3.90**	3.11**	3.07**	3.32**	4.75**	5.11**	3.78**
33	6.59**	5.39**	5.39**	7.95**	3.62**	5.48**	2.09*	4.65**	2.68*
34	2.77**	3.18**	3.77**	2.81**	1.53	2.64*	2.02*	2.11*	4.49**
35	4.33**	4.83**	5.44**	5.94**	3.95**	4.46**	3.60**	4.58**	3.94**
36	4.99**	3.78**	4.63**	4.87**	4.37**	3.85**	1.83	1.14	2.62*
37	10.61**	7.67**	8.54**	3.16**	1.46	3.45**	10.88**	6.99**	8.90**
38	6.12**	5.16**	2.03*	0.86	1.10	1.29	8.48**	6.87**	2.34*

Notes: * significant at 5% ** significant at 1%. The table reports the F-statistic for the following tests. Testing for two structural breaks against the null of no structural breaks involves running the regression with two sets of interaction terms, and testing for the joint significance of all interaction terms. Testing for a structural break in 1985 assuming a structural break in 1991 involves running the regression with two sets of interaction terms, and testing for the joint significance of the 1985 interactions. Testing for a structural break in 1991 assuming a structural break in 1985 is performed analogously. TFP refers to whether or not the specification includes TFP and its interaction terms, and Controls refers to whether or not the specification includes political and market access controls and their interaction terms. The critical values at the 5 and 1 percent levels of the F statistic are:
Column (1): $F(22, 72)=1.68, 2.09$. Column (2): $F(36, 48)=1.65, 2.04$.
Column (3): $F(58, 18)=2.02, 2.75$. Columns (4) and (7): $F(11, 72)=1.90, 2.47$.
Columns (5) and (8): $F(18, 48)=1.80, 2.32$. Columns (6) and (9): $F(29, 18)=2.11, 2.92$.

Table 3.13: Test for the presence of two structural breaks in 1985 and 1991.

We also test for the presence of two structural breaks, against three different null hypotheses: no structural breaks, a structural break in 1985, and a structural break in 1991. For example, testing for two structural breaks against a null of one structural break in 1985, involves an F-test of the joint significance of the interaction terms associated with the break in 1991. The results are in Table 3.13. The null of no structural breaks is rejected in favour of two structural breaks, for all industries in all specifications, except for the specification including TFP, where the null is not rejected for industries 21 (food products) and 27 (wood products). Testing for the presence of a structural break in 1985 when we assume a structural break in 1991 produces less strong results, although the null (that there is a break in 1991 but not in 1985) is still rejected for the majority of industries in all specifications. Finally, testing for a structural break in 1991 assuming a structural

	Break in 1991				Break in 1985			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Test	Endow	TFP	Controls	State	Endow	TFP	Controls	State
Industry	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat	F-stat
20	0.52	6.07**	3.48**	2.58*	0.27	4.09**	1.03	1.63
21	3.26*	1.87*	1.69	1.37	0.91	1.06	0.43	0.55
22	13.65**	2.63**	2.89*	4.45**	1.59	0.98	0.66	0.67
23	1.78	3.27**	2.69*	2.16	1.19	2.07*	2.96*	5.39**
24	0.54	6.16**	4.41**	3.55**	2.20	3.74**	2.99*	3.04**
26	5.45**	6.37**	1.76	5.13**	2.23	1.53	1.39	2.01
27	0.71	1.03	0.66	0.78	1.89	0.60	0.85	0.70
28	2.70	3.72**	1.75	2.39*	2.19	2.06*	2.54*	2.77*
29	5.37**	3.39**	6.68**	6.92**	1.74	0.68	1.29	1.76
30	2.08	2.12*	1.99	1.82	5.46**	2.58**	3.01**	3.92**
31	1.27	4.61**	0.96	1.01	2.08	2.10*	2.04	2.47*
32	2.66	3.04**	3.08**	2.70*	0.95	1.68	4.56**	3.88**
33	3.19*	1.79	2.02	2.06	2.76	1.79	1.83	2.65*
34	4.32*	5.75**	4.79**	5.08**	5.29**	0.92	1.05	1.66
35	4.68**	3.81**	5.58**	4.21**	3.60*	2.30*	5.18**	4.39**
36	5.55**	2.40**	1.49	3.08**	4.38**	2.56**	6.18**	9.20**
37	3.51*	5.58**	5.74**	5.31**	6.15**	1.64	4.50**	2.72*
38	2.69	2.28*	2.67*	2.73*	1.38	0.88	0.67	0.83

Notes: * significant at 5% ** significant at 1%. The full specification, including endowments, TFP, controls, and state and year effects, and a full set of interactions, is run twice: once for a break in 1991, and once for a break in 1985. The table reports the F-statistic for the test that the interaction terms of subsets of RHS variables are jointly insignificant. Endow is the test of the joint significance of the endowment interactions. TFP is the test of the joint significance of the TFP interactions. Controls is the test of the joint significance of the political and market access interactions. State is the test of the joint significance of the state interactions. The critical values at the 5 and 1 percent levels of the F statistic are:
Columns (1) and (5): F(3, 39)=2.85, 4.33. Columns (2) and (6): F(18, 39)=1.85, 2.39.
Columns (3) and (7): F(8, 39)=2.19, 3.01. Columns (4) and (8): F(8, 39)=2.19, 3.01.

Table 3.14: Structural breaks in subsets of RHS variables.

break in 1985, we reject the null that there is a break in 1985 but not in 1991, for the majority of industries in all specifications.[32]

Finally, we can test for structural breaks in subsets of the RHS variables. This simply involves an F-test of the interaction terms of the subset for which we want to test. We divide the RHS variables into four groups: factor endowments, TFP, all controls (political and market access), and state effects. The regression we run is with a single set of interaction terms, either for a break in 1985 or 1991. Table 3.14 shows the results.

For the test of a break in 1991, there is evidence of a structural break in at least one subset of RHS variables in all industries except industry 27 (wood products). For the break in 1985, six industries showed no evidence of a structural break in any sub-

[32] When testing for two structural breaks, we are unable to test for a break for the full specification including endowments, TFP, and political and market access controls, because of insufficient degrees of freedom.

set of variables: industries 21 (food products), 22 (beverages and tobacco), 26 (textile products), 27 (wood products), 29 (leather products), and 38 (other manufacturing). In 1991, there is most evidence of a structural break (in terms of having the largest number of significant coefficients) in the TFP effects, while in 1985 the state effects have the largest number of significant coefficients. For both years, there is least evidence of a structural break in the effect of the factor endowments. Because the degrees of freedom differs across columns, although the values of the F-statistic in columns (1) and (5) appear large, this does not reflect the size of the rejection as the critical values of the F statistic are also larger in those columns.

While Tables 3.12, 3.13 and 3.14 present the summary results of reform on the relationship between factor endowments, technology, and industry share for various specifications, Table 3.15 reports the detailed results for one of these regressions. It presents the results for a single structural break, corresponding to the reform of 1991, for the specification including factor endowments and TFP but not including any political or market access controls. These are the results which are summarised in column (3) of Table 3.12.

In Table 3.15, own TFP is significantly positively associated with industry share in 16 of our 18 industries. The interaction term between the reform dummy and own TFP, is significant and positive in six industries: industries 20 (food products), 24 (man-made textiles), 26 (textile products), 30 (chemical products), 37 (transport equipment) and 38 (other manufacturing). The interaction term of own TFP with the reform dummy is negatively associated with industry share post-reform in four industries: industries 21 (food products), 23 (cotton textiles), 31 (rubber and plastic) and 34 (metal products). This suggests that, for the first six industries, the positive relationship between own TFP and industry share became larger after the 1991 reform, whereas in the latter four industries, this positive relationship became smaller; the point estimates of the coefficients show that in no case does the net effect become negative (the net effect is obtained by adding the interaction term and the non-interacted term).

For factor endowments, the pattern of results is much more mixed. There is, as with previous results, some evidence that factor endowments are more significantly associated with industry share in heavy industries (industries 30 to 37) than in light industries (industries 20 to 29). However, there is no evidence that the reform has had a larger

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dep. Var.	share20	share21	share22	share23	share24	share26	share27	share28	share29
Log real fixed capital	0.032	0.012	-0.141	-0.234	0.215	0.079	0.013	0.04	0.095
	(0.22)	(0.13)	(1.32)	(0.84)	(1.33)	(0.76)	(0.25)	(0.40)	(0.97)
Log literates	1.94	-0.844	-1.759	-6.194	-0.097	-0.397	0.049	-0.27	-0.323
	(1.96)+	(1.45)	(2.53)*	(3.38)**	(0.09)	(0.58)	(0.14)	(0.41)	(0.51)
Log illiterates	-1.971	0.851	1.88	6.365	-0.104	0.3	-0.053	0.196	0.208
	(1.87)+	(1.37)	(2.53)*	(3.25)**	(0.09)	(0.41)	(0.15)	(0.28)	(0.31)
Log crop area	-0.001	-0.02	0.02	0.063	-0.015	0.017	-0.009	0.034	0.02
	(0.01)	(0.49)	(0.43)	(0.50)	(0.20)	(0.36)	(0.38)	(0.74)	(0.45)
Own TFP	0.077	0.167	0.123	0.618	0.111	0.134	0.026	0.234	0.008
	(2.37)*	(6.27)**	(4.02)**	(5.66)**	(2.08)*	(5.48)**	(1.37)	(8.25)**	(0.37)
R*Log real fixed	0.12	-0.193	0.598	0.21	-0.212	0.142	0.03	-0.268	0.051
capital	(0.44)	(1.29)	(3.29)**	(0.46)	(0.76)	(0.72)	(0.30)	(1.49)	(0.29)
R*Log literates	-1.778	1.512	1.433	4.471	-1.064	-4.404	0.253	0.574	0.358
	(0.75)	(1.14)	(0.90)	(1.11)	(0.43)	(2.60)**	(0.30)	(0.36)	(0.23)
R*Log illiterates	1.048	-0.153	-1.981	-8.438	0.973	5.14	0.002	0.061	-3.704
	(0.42)	(0.11)	(1.17)	(1.92)+	(0.37)	(2.92)**	(0.00)	(0.04)	(2.32)*
R*Log crop area	0.61	-1.167	-0.05	3.756	0.304	-0.878	-0.285	-0.367	3.295
	(0.45)	(1.51)	(0.05)	(1.51)	(0.21)	(0.92)	(0.62)	(0.41)	(3.74)**
R*own TFP	0.283	-0.054	0.014	-0.413	0.331	0.237	-0.017	-0.056	-0.013
	(3.80)**	(1.68)+	(0.35)	(2.91)**	(3.77)**	(3.69)**	(0.59)	(1.07)	(0.32)
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	147	147	147	147	147	147	147	147	147
R-squared	0.9	0.9	0.94	0.94	0.94	0.94	0.62	0.89	0.93

	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Dep. Var.	share30	share31	share32	share33	share34	share35	share36	share37	share38
Log real fixed capital	0.525	0.037	0.086	1.172	0.064	0.102	-0.477	-0.027	-0.008
	(1.33)	(0.07)	(0.88)	(5.33)**	(0.70)	(0.70)	(2.31)*	(0.08)	(0.12)
Log literates	-1.653	-1.624	0.763	-2.753	-2.006	0.95	-0.401	9.668	0.191
	(0.64)	(0.47)	(1.19)	(1.90)+	(3.45)**	(0.99)	(0.30)	(4.51)**	(0.41)
Log illiterates	1.341	1.626	-0.856	1.593	1.952	-1.108	1.133	-9.487	-0.102
	(0.49)	(0.44)	(1.25)	(1.03)	(3.12)**	(1.08)	(0.78)	(4.14)**	(0.20)
Log crop area	-0.214	-0.039	0.007	-0.012	-0.009	0.055	-0.255	-0.154	-0.08
	(1.20)	(0.16)	(0.17)	(0.12)	(0.24)	(0.85)	(2.74)**	(1.05)	(2.53)*
Own TFP	0.587	1.522	0.223	0.359	0.357	0.885	0.713	0.328	0.065
	(5.44)**	(12.91)**	(7.47)**	(6.92)**	(9.69)**	(12.13)**	(8.88)**	(2.93)**	(2.91)**
R*Log real fixed	1.177	0.642	0.013	-0.272	0.331	0.313	1.083	0.307	-0.088
capital	(1.72)+	(0.75)	(0.07)	(0.71)	(1.93)+	(1.15)	(2.84)**	(0.55)	(0.65)
R*Log literates	0.766	9.728	-1.754	7.299	1.296	3.684	-4.791	-5.618	0.914
	(0.12)	(1.29)	(1.09)	(2.15)*	(0.89)	(1.52)	(1.44)	(1.09)	(0.78)
R*Log illiterates	-7.454	-5.407	-0.093	-4.605	-0.764	0.948	3.651	2.178	-1.445
	(1.14)	(0.65)	(0.06)	(1.28)	(0.51)	(0.38)	(1.05)	(0.40)	(1.21)
R*Log crop area	5.511	-4.963	1.835	-2.422	-0.863	-4.945	0.057	3.134	0.619
	(1.52)	(1.05)	(2.07)*	(1.22)	(1.09)	(3.78)**	(0.03)	(1.06)	(0.96)
R*own TFP	0.725	-1.187	0.041	-0.047	-0.253	-0.11	0.062	0.736	0.12
	(1.91)+	(5.43)**	(0.64)	(0.47)	(3.34)**	(0.82)	(0.32)	(3.03)**	(2.68)**
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	147	147	147	147	147	147	147	147	147
R-squared	0.97	0.82	0.95	0.8	0.93	0.97	0.92	0.93	0.91

Absolute value of t statistics in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. Estimation method is SURE with linear homogeneity and cross-equation TFP constraints. The dependent variable shareXX refers to the share of industry XX in a state's GDP. Real fixed capital is the total depreciated value of fixed assets in industry, deflated by an industry-level price deflator for machinery and transport equipment. Literates and illiterates are the number of people who are literate and illiterate in a state. Crop area is the total area under crops, measured in thousands of hectares. The interaction terms are R*variable, where R is a dummy variable taking value 0 before 1991, and 1 after 1991. Own TFP refers to the impact of the industry's own TFP on its share of output; cross industry TFP coefficients not reported. See the Data Appendix for details of the construction and sources of the variables.

Table 3.15: Regression (3.18) with a reform dummy in 1991.

effect on the relationship between factor endowments and industry share in heavy industries than in light industries. The direction of change indicated by the interaction terms is also interesting. For example, in industry 33 (basic metals), the endowment of literates was negatively related to industry share before reform, but the interaction term is positive, and the net effect post-reform is positive. Similarly, in industry 36 (machinery and equipment), capital stock is negatively related to industry share before reform, whilst the interaction term is positive, yielding a net effect post-reform which is positive. This interesting pattern of results is not unexpected, since as noted above, with more industries than factors of production, the relationship between industry share and factor endowments holds only in terms of correlations. It is therefore difficult to draw any sharp conclusions from the results of Table 3.15.

All in all, the results of Tables 3.12, 3.13, 3.14 and 3.15 show that the reform of the Indian economy begun in 1985 and 1991 had extremely diverse and significant impacts on the different industries in India.[33] The reform of the Indian economy changes the relationship between factor endowments, technology, and industrial structure. This is consistent with the idea that the relationship between these variables is different in a centrally planned economy than in a market-orientated economy.

3.5 Summary and Conclusions

The objective of this chapter is to understand industrial structure across the states of India: what it looks like, and how observed structures may be explained. To do so, we use a neoclassical trade model, relating industrial structure to differences in factor endowments and technology across locations, which has been used successfully in explaining industrial structure in more developed countries. This allows us to consider the extent to which such a neoclassical model can be successfully used for developing countries. Our dataset, which is a panel of 16 states and 18 industries from 1980 to 1997, covers a period of change in the policy environment towards private economic activity in India. We are therefore able to consider the impact of these economic reforms on the relationship between factor endowments, technology, and industrial structure.

[33] See Aghion, Burgess, Redding and Zilibotti (2004) on the uneven impact of liberalisation on productivity and output across Indian industries.

Our main results are as follows. First, we find evidence of improvements in average TFP over time. However, there is also great heterogeneity in TFP performance across states and industries, with some industries not exhibiting any growth in TFP. Second, both factor endowments and technology are strongly related to the location of industries. The only exceptions to this are those industries which are agriculture based, as our measure of crop area may not capture how suitable the land is for different types of agriculture. Capital stock, and skilled and unskilled labour, have more statistically significant associations with the structure of production than agricultural land area. Higher levels of technology in an industry are associated with a larger share of that industry in a state.

Third, the results on the relationship between factor endowments, technology and industry shares, are robust to the inclusion of additional variables controlling for political factors and market access. The different political parties relate to industry shares in the same direction. Fourth, domestic and foreign market access relate to industry share in the same direction; access to markets applies to both domestic and foreign markets. In terms of economic importance of the explanatory variables, factor endowments, political history and market access are the most important, while TFP, while frequently statistically significant, has a much smaller impact on industrial structure.

Our fifth main result is that there is strong evidence of structural breaks in Indian industry in 1985, at the start of Rajiv Gandhi's initial reforms, and in 1991, when a more general liberalisation was put into effect. Our results indicate that the change from a centrally planned economy to a more market orientated economy has changed the relationship between factor endowments, technology and industrial structure.

In conclusion, the neoclassical model, when suitably extended, provides a relatively successful explanation of the pattern of production across regions within a developing country such as India. Its application is not therefore limited to the developed world, and it provides a suitable framework for exploring the impact of market orientated reforms on industrial structure.

3.A Data Appendix to Chapter 3

The data comes from many sources. Our dataset builds on Ozler, Datt and Ravallion (1996) and Besley and Burgess (2004).

The labor regulation variable comes from state-specific text amendments to the Industrial Disputes Act 1947 as reported in Malik (1997). Besley and Burgess (2004) code each change in the following way: a +1 denotes a change that is pro-worker or anti-employer, a 0 denotes a change that was judged not to affect the bargaining power of either workers or employers and a -1 denotes a change which they regard to be anti-worker or pro-employer. There were 113 state specific amendments coded in this manner. Where there was more than one amendment in a year they collapsed this information into a single directional measure. Thus reforms in the regulatory climate are restricted to taking a value of 1, 0, -1 in any given state and year. To use these data, they then construct cumulated variables which map the entire history of each state beginning from 1947 — the date of enactment of the Industrial Disputes Act.

State population data used to express magnitudes in per capita terms comes from the 1951, 1961, 1971, 1981, 1991 and 2001 censuses [Census of India, Registrar General and Census Commissioner, Government of India] and has been interpolated between census years.

State domestic product comes from Estimates of State Domestic Product published by Department of Statistics, Ministry of Planning, Government of India.

Fixed capital and industrial output come from the Indian Annual Survey of Industries, Central Statistical Office, Department of Statistics, Ministry of Planning, Government of India. Fixed capital represents the depreciated value of fixed assets owned by the factory on the closing date of the accounting year. Fixed assets are those which have a normal productive life of more than one year. Fixed capital covers all types of assets new or used or own constructed, deployed for production, transportation, living or recreational activities, hospitals, schools etc. for factory personnel. Industrial output is the total ex-factory value of products and by-products manufactured and receipts from non-industrial services rendered to others, work done for others on materials supplied by them, value of electricity produced and sold, sale value of goods sold in the same condition as purchased, addition in stock of semi-finished goods and own construction.

Literacy is from various issues of the Statistical Abstracts of India, Central Statistical Office, Department of Statistics, Ministry of Planning, Government of India.

The data on political histories comes from Butler, Lahiri and Roy (1991), updated from the website of the Election Commission of India (http://www.eci.gov.in/). Political history is measured by the number if years during our data period that particular political groupings have held a majority of the seats in the legislature. State political configurations are held constant between elections. In our data period, the relevant groupings are: the Congress party, the Janata parties, hard left parties, the Hindu parties, and regional parties. These groupings contain the following parties (i) Congress Party (Indian National Congress + Indian Congress Socialist + Indian National Congress Urs + Indian National Congress Organization), (ii) Janata parties (Lok Dal+Janata+Janata Dal), (iii) a hard left grouping (Communist Party of India + Communist Party of India Marxist), (iv) Hindu parties (Bharatiya Janata Party (BJP)), and (v) a grouping made up of regional parties.

Industry data is from the Indian Annual Survey of Industries (ASI). Data is available at the 3-digit level, following the National Industrial Classification (NIC). The data in the ASI is for registered manufacturing, defined as firms with 20 or more workers but no electrical power, or firms with 10 or more workers and electrical power. There is a change in industrial classification in 1987 and, in order to match the 1970 and 1987 NICs, we aggregate a small number of 3-digit industries. We exclude miscellaneous manufacturing industries, as these are likely to be heterogeneous across states. The industries 'Minting of Currency Coins' and 'Processing of Nuclear Fuels' are also excluded, as outcomes in these industries are likely to be determined by special considerations. This leaves a total of 138 industries, which are then aggregated to the 2-digit level. The dependent variable in the regressions is the share of industry value added in state domestic product. Industry value added is calculated as the sum of net value added and depreciation. This is divided by state domestic product to get the share of an industry.

Market potential is calculated from the formula in the text. Distance data is road distance, from the website http://mapsofindia.com/distances/. Distances between states are road distances between state capitals, and distances between states and ports are road distances between state capitals and ports. Own distance is given by the formula $\frac{2}{3}\left(\frac{area}{\pi}\right)^{\frac{1}{2}}$, which gives the average distance between two points in a circular state. Total trade volume of a port is from various issues of the Statistical Abstract of India.

To calculate total factor productivity using the net value added approach, the following variables from the ASI are used:

Industry level net value added: Defined as the increment to the value of goods and services that is contributed by the factory.

Industry level fixed capital: Defined as the depreciated value of fixed assets owned by the factory.

Industry level workers: Defined to include all persons employed directly or through any agency whether for wages or not and engaged in any manufacturing process or in cleaning any part of the machinery or premises used for manufacturing process or in any other kind of work incidental to or connected with the manufacturing process or the subject of the manufacturing process.

The industry level share of labour in value-added is calculated as the sum of emoluments plus welfare payments, divided by net value added. Emoluments are defined as all remuneration paid to all employees including payments in kind, while welfare payments include provident fund, pension, gratuity, other social security charges, and group benefits like direct expenditure on maternity, creches and canteen facilities.

Net value added, fixed capital and payments to labour are deflated by the industry-level price deflator for Machinery and Transport Equipment, obtained from the Indian Handbook of Industrial Statistics (various issues), 1980-97.

3.B Appendix Tables

20	manufacture of food products
21	manufacture of food products
22	manufacture of beverages, tobacco and related products
23	manufacture of cotton textiles
24	manufacture of wool, silk and man-made fibre textiles
25	manufacture of jute and other vegetable fibre textiles (except cotton and coir)
26	manufacture of textile products (including wearing apparel)
27	manufacture of wood and wood products; furniture and fixtures
28	manufacture of paper and paper products and printing, publishing and allied industries
29	manufacture of leather and products of leather, fur and substitutes of leather
30	manufacture of basic chemicals and chemical products
31	manufacture of rubber, plastic, petroleum and coal products; processing of nuclear fuels
32	manufacture of non-metallic mineral products
33	basic metal and alloys industries
34	manufacture of metal products and parts, except machinery and equipment
35	manufacture of machinery and equipment other than transport equipment
36	manufacture of machinery and equipment other than transport equipment
37	manufacture of transport equipment and parts
38	other manufacturing industries

Table 3.16: India National Industrial Classification (2 digit level).

Dep. Var	(1) share20	(2) share21	(3) share22	(4) share23	(5) share24	(6) share26	(7) share27	(8) share28	(9) share29
Log real fixed capital	0.041	0.031	0.017	-0.156	-0.065	0.069	-0.009	0.016	0.027
	(1.33)	(0.59)	(0.88)	(2.34)*	(1.56)	(2.73)**	(1.13)	(0.85)	(2.35)*
Log literates	0.408	0.398	-0.091	0.111	0.428	-0.365	-0.227	0.038	-0.096
	(2.46)*	(1.45)	(0.89)	(0.31)	(1.94)+	(2.71)**	(5.57)**	(0.37)	(1.58)
Log illiterates	-0.376	-0.38	0.006	-0.03	-0.293	0.177	0.273	-0.213	0.041
	(2.57)*	(1.57)	(0.06)	(0.10)	(1.50)	(1.49)	(7.58)**	(2.35)*	(0.78)
Log crop area	-0.074	-0.048	0.068	0.075	-0.071	0.12	-0.037	0.159	0.028
	(1.09)	(0.43)	(1.64)	(0.52)	(0.79)	(2.18)*	(2.22)*	(3.80)**	(1.13)
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.88	0.91	0.85	0.86	0.87	0.67	0.92	0.86	0.88
Sum of endowment coefficients	0.2203	0.3300	-0.0416	-0.1035	1.0960	-0.5167	0.2272	-0.2051	-0.1536
p-value	0.2965	0.3458	0.7495	0.8188	0.0001	0.0024	0.0000	0.1164	0.0454
Observations	287	287	287	287	287	287	287	287	287

Dep. Var.	(10) share30	(11) share31	(12) share32	(13) share33	(14) share34	(15) share35	(16) share36	(17) share37	(18) share38
Log real fixed capital	0.487	0.247	0.082	-0.125	-0.004	-0.019	0.036	-0.068	0.011
	(4.03)**	(1.90)+	(2.37)*	(0.81)	(0.21)	(0.55)	(0.80)	(0.72)	(1.27)
Log literates	-1.024	-0.649	-0.077	-0.724	-0.168	0.163	-0.066	1.004	0.172
	(1.59)	(0.94)	(0.42)	(0.88)	(1.79)+	(0.87)	(0.28)	(1.97)+	(3.57)**
Log illiterates	0.963	0.297	0.059	0.986	0.17	-0.11	0.072	-0.634	-0.073
	(1.69)+	(0.49)	(0.37)	(1.36)	(2.05)*	(0.67)	(0.34)	(1.41)	(1.72)+
Log crop area	-0.425	0.106	-0.064	-0.137	0.002	-0.034	-0.042	-0.302	-0.11
	(1.62)	(0.38)	(0.85)	(0.41)	(0.05)	(0.45)	(0.43)	(1.45)	(5.62)**
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.91	0.5	0.84	0.86	0.84	0.94	0.88	0.77	0.84
Sum of endowment coefficients	1.4785	-1.2877	0.6505	1.1646	0.0478	0.3251	0.0106	1.6990	0.0087
p-value	0.0707	0.1436	0.0052	0.2660	0.6894	0.1709	0.9722	0.0085	0.8869
Observations	287	287	287	287	287	287	287	287	287

Absolute value of t statistics in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. All regressions run using SURE (Seemingly Unrelated Regression) with the restriction that the coefficients on all endowment variables sum to 0. The dependent variable shareXX refers to the share of industry XX in a state's GDP. Real fixed capital is the total depreciated value of fixed assets in industry, deflated by an industry-level price deflator for machinery and transport equipment. Literates and illiterates are the number of people who are literate and illiterate in a state. Crop area is the total area under crops, measured in thousands of hectares. The sum of endowment coefficients is the sum of coefficients on real fixed capital, literates, illiterates and crop area, if the regression is run without imposing the restriction that they sum to zero. The p-value is the p-value of the F-test that the sum of endowment coefficients is equal to zero, when the regression is run without imposing that restriction. See the Data Appendix for details of the construction and sources of the variables.

Table 3.17: Regression (3.10): factor endowments with homogeneity constraints, full sample.

Chapter 4
Endogenous Economic Policy and the Structure of Production: Theory and Evidence

4.1 Introduction

What role do initial conditions play in determining the pattern of international trade and the location of production? The standard response to this question is to point to the role of increasing returns to scale in production technology, and its role in creating path-dependent outcomes. This is the line of reasoning adopted by many authors including Krugman (1981), Arthur (1989), Krugman (1991), Fujita, Krugman and Venables (1999) and Redding (2002). In this chapter, differently from these previous papers, initial conditions influence the pattern of trade through its impact on policy, which in turn affects agents' locational decisions, and hence the pattern of production and trade.

We propose a model of trade between two locations[34] that makes the following two predictions. First, the location with a greater absolute stock of capital will have policies which are more favourable to capital[35]. Once we allow for capital to move across locations, the location with greater absolute capital stock will attract inflows of capital from the other location, changing relative capital-labour endowments, so that the location with an initial absolute advantage in capital stock, will end up having a comparative advantage in the capital intensive good. Therefore, the second theoretical prediction is that locations with more different policies will also have more different industrial structures. Both of these predictions are then tested empirically.

[34] The mechanism underlying the model are more general than the precise two location setup, and could be extended to multiple locations.

[35] A note on terminology: we use "locations" to distinguish between geographical areas. We prefer this term to alternatives such as "countries" or "states" as the mechanism in the model would operate irrespective of the geographical area involved, as long as different locations have different policies and capital is mobile between locations.

The way the model works is as follows. We start with a standard model of trade with identical technologies but different relative endowments of capital and labour across locations. Then, comparative advantage implies that each location will export the good which uses intensively its relatively abundant factor. However, capital owners are able to lobby the government for policies that favour them, at the expense of labour; labour owners as assumed to be unorganised and hence unable to counter-lobby the government. The location with greater absolute levels of capital will therefore implement policies that are more favourable to capital, because the cost of policy is spread over more units of capital.[36]

Once we allow for capital mobility, lobbies in each location play a two stage game in which they first simultaneously choose whether to lobby their respective governments or not, and then whether to stay in their original location or move to the other location. In general there are two (pure strategy) subgame-perfect Nash equilibria, in which all the capital in the world locates in either location. However, if initial absolute capital endowments are different across locations, the two equilibria are not symmetric, and we can obtain conditions for which one of the equilibria disappears leaving us with a unique Nash equilibrium, that all the capital in the world will locate in the location that has the larger initial stock of capital. This somewhat extreme outcome is a result of a simplifying assumption we make on the technology side which makes the model much simpler to solve. Relaxing this assumption would result in incomplete capital relocation, which is what is observed in reality. Therefore, while comparative advantage matters for current patterns of trade, initial absolute endowments of capital determine policies and hence the future location of capital, future comparative advantage, and future patterns of production. This can lead either to the reinforcement or reversal of initial comparative advantage.

The key contribution of this chapter is to combine the microfoundation of policy with comparative advantage and trade patterns. Following the lead of Grossman and Helpman (1996), we endogenise the relative weights which the government places on campaign contributions versus voter welfare, and show that the share of tax revenue derived from capital depends on how effective is lobbying activity, how dispersed are voter

[36] If the government-provided good is a public good that is nonrival in consumption, e.g. national defence, then the benefits of government policy do not decline with the units of capital.

preferences for different parties in an election, and how well-informed are voters. Our two main contributions relative to Grossman and Helpman (1996) are, first, to incorporate a Heckscher-Ohlin production structure with two sectors that use two factors of production with different intensities. Second, we allow for capital mobility across locations. Both of these new dimensions of the analysis substantially change the predictions of the model.

There have been previous models on the impact of endogenous policy formation on capital mobility; examples include Persson and Tabellini (1992) and Haufler (1997). At least two key features distinguish our model from previous models. First, it is based on a two-good, two-factor model of international trade; this allows us to derive some results on the impact of factor mobility on the structure of production. Second, and fairly crucially for our results, the government in our model maximises the probability that it will win an election. In the process of doing so, it has to compete with a rival party using a combination of campaign contributions and policies, but this results in the capital lobby being able to exploit this rivalry to maximise its own welfare at the expense of the political parties.

The model of absolute advantage which we present also differs from previous models in which absolute advantage is an explanation for trade, for example Copeland and Kotwal (1996), Ricci (1999) or Neary (2003). In Copeland and Kotwal (1996), absolute (technological) advantage combined with non-homothetic preferences may lead to no gains from trade, so that absolute advantage reduces trade flows. Ricci (1999) allows for technological differences across locations in a two-location model of economic geography with increasing returns at the level of the firm, and finds that agglomeration may occur in the location with an absolute technological disadvantage, if the difference in productivities between the two countries is not too large. In Neary (2003), a fall in production costs in one country in a many-sector oligopolistic general equilibrium model may lead both countries to specialise less in accordance with comparative advantage through changes in factor prices. Differently from these papers, in our model, absolute advantage in terms of initial absolute capital stock has an indirect effect on patterns of trade, by influencing the location of capital through its impact on policy. Trade in goods, taking factor endowments as given, is still governed by comparative advantage.

This chapter is also related to the literature on tax competition. The evidence from this literature has been that corporate tax revenue as a share of total tax revenue has been falling in OECD countries over the last 30 years (see e.g. Devereux, Griffith and Klemm (2002)). The traditional tax competition literature has emphasised a race-to-the-bottom as countries compete with one another to capture internationally mobile capital. However, Baldwin and Krugman (2002) show that, empirically, there is no clear evidence of a race to the bottom, and they develop a theoretical model of economic geography which predicts that closer integration between countries may lead first to a race-to-the-top and then a race-to-the-bottom. The model in the present chapter predicts no race of either kind, as governments are compelled to implement policies subject to the special interest groups' interests.

In the theoretical model, we model the government's policy variable as the tax rate on capital and labour. In our empirical analysis, we take a broader interpretation of policy. We test for the impact of capital endowments on economic policy using state-level data on India between 1959 and 1997, using Besley and Burgess' (2004) labour regulation indicator as a measure of how favourable is the policy stance of a state to capital.

Since capital stock is endogenous in our model, our empirical strategy uses instrumental-variables methods to overcome this problem. We instrument capital stock using electricity generating capacity and bank credit. These are intuitively appealing instruments as they are highly correlated with capital stock, but at the same time, are not correlated with the error term, as they are primarily determined by the central government. Burgess and Pande (2004) present evidence that the location of bank branches in India was largely driven by the Banking Regulation Act of 1949, which requires banks to obtain a license from the central bank of India before opening a new branch. This effectively gave the central bank control over the location of bank branches. Under the Industrial Policy Resolution of 1956, the generation and distribution of electricity was one of the industries placed under the exclusive responsibility of the central government, and was a part of the central government policy to reduce regional disparities in income and wealth. Both instruments therefore are controlled by the central government and should be uncorrelated with the error term. The instrumental variables estimates passed the Hansen (1982) test of overidentification. As an additional robustness check, we use ordered logit as an alternative estimation method, due to the discrete nature of the labour regulation variable.

Both predictions of our theoretical model are confirmed in the data. First, even after controlling for numerous other factors, absolute capital endowments have a strong impact on policy. More precisely, the greater the endowment of capital in a state, the more pro-capital will be its policy stance. We see this as evidence in support of the mechanism proposed in our theory. Second, states which are more similar in their labour regulations, tend to have more similar industrial structure, which again is in accord with the theoretical prediction.

Our empirics differ from previous work such as Besley and Burgess (2000, 2004), Aghion, Burgess, Redding and Zilibotti (2004) and Dollar, Iarossi and Mengistae (2002), who focus on the impact of policy on economic performance. Here, in our first main econometric specification, we use a measure of policy as our dependent variable, and investigate the impact of capital endowments on policy. In our second main estimated equation, we also investigate how differences in policy across states impact on industrial structure.

The rest of the chapter is structured as follows. The next section lays out the theoretical model, starting with a closed economy and then allowing for capital mobility and trade across locations. Section 4.3 performs the empirical tests. The final section concludes.

4.2 The Model

The model combines elements of both a model of political economy and a model of trade based on factor endowments. First, we describe the production side of the economy, which is a $2 \times 2 \times 2$ Heckscher-Ohlin model. Assume two locations, Home and Foreign, two goods, 1 and 2, and two factors of production, capital and labour, both inelastically supplied. The two goods are produced under perfect competition using the following technologies which are assumed to be identical across locations:

$$X_1 = x_1(K) \qquad X_2 = x_2(L) \tag{4.1}$$

That is, capital is the only factor of production used in producing good 1, while labour is the only factor of production used in producing good 2. These production technologies ensure that, in the presence of free trade in goods, factor prices are equalised at every point in the Edgeworth Box, which simplifies the analysis considerably, and also give rise to the result of complete relocation of capital between locations when capital mobility is allowed. The production technologies are specialised versions of the more general case where $X_1 = x_1(K, L)$ and $X_2 = x_2(K, L)$ with good 1 capital-intensive relative to good 2 at any given factor price.

Equilibrium in production is given by the set of equilibrium conditions familiar from standard trade theory (see Helpman and Krugman (1985)):

$$p_i = MC_i(w, r) \tag{4.2}$$

$$\begin{aligned} l_2(w) X_2 &= \overline{L} \\ k_1(r) X_1 &= \overline{K} \end{aligned} \tag{4.3}$$

$$\begin{aligned} \lambda_1(p_1, p_2) &= \frac{p_1 X_1}{p_1 X_1 + p_2 X_2} \\ \lambda_2(p_1, p_2) &= \frac{p_2 X_2}{p_1 X_1 + p_2 X_2} \end{aligned} \tag{4.4}$$

where the first condition is simply the zero profit condition, the second condition is the factor market clearing condition, where l_i and k_i are the unit factor input requirements, and the third condition is the goods market clearing condition, where $\lambda_1(p)$ and $\lambda_2(p)$ are the shares of goods 1 and 2 respectively in total expenditure.

The political model is based on a heavily modified version of Grossman and Helpman's (1996) model of electoral competition and special interest politics; our exposition actually follows Chapter 10 in Grossman and Helpman (2001) more closely. The main difference between our model and theirs is that we extend their framework to consider the role of factor endowments on policy, and the impact of policy on the industrial structure, which enables us to derive a number of new results linking policy, factor location and production structure. Reflecting the Heckscher-Ohlin nature of the model, special interests are defined along factor lines, as capital owners and labour owners, respectively. Instead of their policy vector, we consider a simpler setup with only a single policy instrument, which may favour either capital or labour.

We divide consumers into those who own labour, whose net labour income is WL, and those who own capital, whose net capital income is RK. This is a simple way of capturing the reality that the main source of income is labour wage for some agents in society, and capital rents for other agents, while avoiding issues related to the distribution of wage versus rental income. The model is set up so that capital and labour have opposing interests. This is in line with recent evidence which suggests that individual preferences are split along factor endowment lines (see for example Mayda and Rodrik (2004), O'Rourke (2003), O'Rourke and Sinnott (2001), Scheve and Slaughter (2001)).

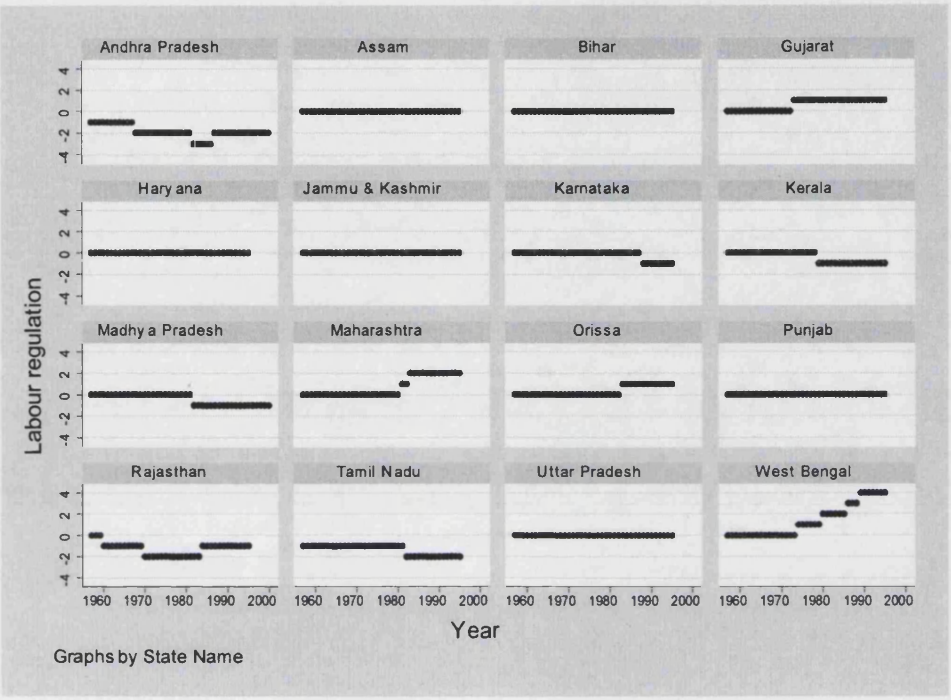
Also, suppose that capital owners do not vote, while all labour owners vote. All capital owners form a single special interest group (SIG) which can lobby the government, while labour is unorganised. The assumption that all labour owners vote captures the idea of universal suffrage in modern democracies, while the assumption that labour does not lobby the government captures the problems of organising a special interest group, when each agent is small relative to the group as a whole (although in reality, labour unions may overcome these concerns). Allowing capital to lobby the government captures the fact that capital ownership is highly concentrated so that capital is easier to organise as a special interest group, while not allowing capital to vote captures the fact that capital's influence on the policy process through voting is small relative to its potential to lobby the government.

4.2.1 Modelling the policy instrument

The data we use for the empirical section uses Besley and Burgess' (2004) indicator of labour regulation as pro-worker or pro-capital. Therefore, we would like to model the policy instrument in the same way. First, we give a brief description of the labour regulations as used in Besley and Burgess (2004), then we explain our modelling procedure.

The legislation which Besley and Burgess use is the Industrial Disputes Act of 1947. This is a Federal Act, enacted in 1947, and falls under the Concurrent List, for which both central and state governments are allowed to make law. Besley and Burgess consider state-level amendments to the Act, as listed in Malik (1997). Therefore, while under the Federal Act all states started out with the same level of policy, these state-level amendments mean that they have diverged over time.

Figure 4.1: Labour regulation in India, 1958-1997.



Besley and Burgess code 113 amendments to the Act, as either pro-employer, pro-worker, or neutral. An amendment is coded as +1 if it is pro-worker, -1 if it is pro-employer, and 0 if it is neutral, with multiple amendments in the same direction in the same year given the same coding as if it is a single amendment (for further details, see Besley and Burgess (2004)). Therefore, the measure of labour regulation captures the net direction of change in any one year. Figure 4.1 shows the trends in the policy measure across states. Six states which have made no amendments to the Industrial Disputes Act can be classified neutral or control states: Assam, Bihar, Haryana, Jammu & Kashmir, Punjab and Uttar Pradesh. The treatment states are either pro-employer (six states: Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, Rajasthan and Tamil Nadu) or pro-worker (four states: Gujarat, Maharashtra, Orissa and West Bengal).

What exactly are these changes in labour regulation? The Appendix Table in Besley and Burgess (2004) lists all the changes. Examples of pro-worker regulation include requiring workers to be paid before closing down firms, giving preference to prior workers when rehiring, allowing individual workers to apply to the labour court for adjudication, widening judicial powers to recover money owed to workers by employers, and lengthening the notice employers must give workers about changes in the condition of service. Examples of pro-employer regulation include prohibiting strikes and lockouts when in the public interest, facilitating the settlement of industrial disputes in labour courts, and allowing firms to continue layoffs due to natural disasters for more than 30 days without requiring permission from the government.

Our simple model is of course unable to capture all the richness of the policy environment in India. Nevertheless, the message that comes through very clearly in the policy changes noted above is that any given policy change generates a benefit to capital or labour, and a policy that favours capital tends to hurt labour. To keep the model simple, we model the policies as tax rates on labour and capital, although we want to keep in mind that this is a simplification of the much more complex policies involved. Let the policies toward labour and capital be related in the following manner:

$$t^L L + t^K K = G \tag{4.5}$$

That is, there is a government revenue requirement that is satisfied by taxes on capital and labour. Assume that t^K, $t^L \geq 0$; the government cannot subsidise factors. This is a fairly crucial assumption. First, in the absence of lobbying activity by capital, it prevents the political parties from attempting to win votes from labour by taxing all of capital income and transferring the surplus to labour. Second, while more capital is associated with a lower tax rate on capital when a given quantity of revenue needs to be raised from capital, conversely, more capital is associated with a lower subsidy rate when capital is being subsidised.

This formulation of policy, where the government revenue requirement is independent of capital and labour stocks, is what drives the result that it is absolute factor endowments that matters. Doubling capital and labour stocks will halve the tax rates on capital and labour. This may be rationalised on the grounds that there are fixed costs and scale economies in the supply of public goods, because these goods are non-rival in consumption. As Alesina and Wacziarg (1998) note, there are fixed costs in establishing a set of institutions, and a legal, monetary and fiscal system. The costs of certain public goods such as parks, libraries, roads and telecoms infrastructure, grow less than proportionally with the size of the population. Alesina and Spolaore (1997), for example, use a government cost that is independent of country size in their model of the number and size of nations. There is also strong evidence that the share of government expenditure in GDP decreases as country size (as measured by total GDP) increases; see for example Alesina (2003) or Alesina and Wacziarg (1998). However, this assumption is stronger than is required; it can be shown that the key result, that the tax rate on capital decreases the more capital there is in the economy, will go through as long as there are some constraints on the parameter values, for alternative specifications of the government budget constraint. The cost of relaxing this assumption is a more complicated expression for tax rates, which would make the extension of allowing for capital mobility analytically intractable.

Therefore, the net return to labour is $W = w - t^L$, while the net return to capital is $R = r - t^K$.[37] Interpreted in this way, policy is more favourable to capital the lower is the tax rate on capital. We believe that other formulations of policy that involve a transfer of resources between factor owners should yield similar results. Since it is factor owners rather than firms who pay the taxes, these taxes do not influence the firms' decisions: firms will maximise their profits taking pre-tax wage and rental rates as given. This allows us to retain the Factor Price Equalisation result, which simplifies the model considerably.

We now establish a link between the way we have modelled the policy, with the actual policies we use in our empirical work. The tax rates in the model may be thought of as the monetary equivalent of the cost of the labour regulations imposed on labour or capital owners in the data. Our interpretation of events is as follows. All states started out at the same level of tax rates (policy) on capital in 1947. But after that, lobbying activity in individual states changes the policy to reflect the political equilibrium in each state, with the result (to be shown below) that the more capital there is in a state, the more favourable to capital will be the policy.

[37] Modelling policy as multiplicative rather than additive as we do here does not change the basic insight of the model.

4.2.2 Political environment and equilibrium without capital mobility

First, consider the case without capital mobility. We seek a subgame-perfect Nash equilibrium of a two-stage political game. The timing of the game is as follows:

(1) In Stage 1, interest groups announce their contribution schedules to each party.

(2) Then in Stage 2, parties choose their policy platforms. Contributions are paid and campaigns are waged. The election takes place and the legislature meets to implement the winning party's platform. Finally, output is produced and factors are paid.[38]

Let W^A and W^B be the return to labour net of the policy implemented by parties A and B. Substituting from the government budget constraint (4.5), we get the welfare of voters given the policy platform of each party:

$$\begin{aligned} W^A &= w - t^{LA} \\ &= w + t^{KA}\left(\frac{K}{L}\right) - \frac{G}{L} \qquad (4.6) \\ W^B &= w - t^{LB} \\ &= w + t^{KB}\left(\frac{K}{L}\right) - \frac{G}{L} \qquad (4.7) \end{aligned}$$

where t^A, t^B are policy platforms of parties A and B. This implies that voter welfare is linear in income.

First, we discuss the behaviour of voters. There are two classes of voters: informed and uninformed, and two political parties, A and B. A two-party system is a reasonably close approximation of the politics of many countries, for example the Republicans and the Democrats in the United States, the Labour party and the Conservative party in the United Kingdom, or Congress and the BJP (Bharatiya Janata Party) in India.

Informed voters are those who are aware of each party's platforms, and vote based on the policy platforms and other characteristics of each party. Let $(1-\alpha)$ denote the fraction of informed voters in the total voting population. Voters differ in their preferences for each party's exogenous characteristics; let β^i measure voter i's assessment of the superiority of party B's exogenous characteristics relative to party A, drawn from a

[38] Since contributions are paid before factors are paid, we implicitly assume that there are perfect financial markets on which factors can borrow/lend costlessly.

uniform distribution on $\left(-\frac{1}{2f}-\frac{b}{f},\frac{1}{2f}-\frac{b}{f}\right)$, where $f>0$ is a parameter measuring the diversity of ex ante views about the parties. The parameter b can be interpreted as the ex ante voter bias in favour of party A. We might expect $b>0$ if party A is the incumbent party, and $b<0$ if party B is the incumbent party. An informed voter i votes for party A only if $W^B - W^A \leq \beta^i$, or if the net return to labour under party A's policy is greater.

Then the total number of informed votes cast for party A equals

$$\begin{aligned} s^I &= \left[\frac{1}{2}+b+f\left(W^A-W^B\right)\right](1-\alpha)L \\ &= (1-\alpha)\left[\left(\frac{1}{2}+b\right)L+f\left(t^{KA}-t^{KB}\right)K\right] \end{aligned} \tag{4.8}$$

where the second row is obtained by substituting for W^A and W^B from equations (4.6) and (4.7). Uninformed voters (making up the remaining fraction α of the voting population) vote based on campaign spending by the two parties, and party characteristics. A party would be able to attract more uninformed voters to vote for it if it spends more than its rival in its campaign. Hence, denote by s^U the number of uninformed voters who vote for party A, and assume that it depends on the difference in the parties' total campaign budgets:

$$s^U=\left(\frac{1}{2}+b\right)\alpha L+h\left[\left(C^A\right)^{\frac{1}{2}}-\left(C^B\right)^{\frac{1}{2}}\right] \tag{4.9}$$

where $h>0$ is a parameter reflecting the productivity of campaign spending, and C^P is total campaign spending by party P, $P=A,B$. This specification shows that there are diminishing returns to campaign spending. This is a natural assumption to make, as more effective campaigning methods are used first, followed by less effective methods. Assume that the voter bias b is the same for both groups of voters.

The total number of votes won by party A (denoted s; this implies that party B wins $1-s$) is the sum of informed and uninformed votes:

$$\begin{aligned} s &= s^I+s^U \\ &= \left(b+\frac{1}{2}\right)L+(1-\alpha)f\left(W^A-W^B\right)L+h\left[\left(C^A\right)^{\frac{1}{2}}-\left(C^B\right)^{\frac{1}{2}}\right] \end{aligned} \tag{4.10}$$

Now we discuss the behaviour of political parties. Each party is committed to implementing its policy platform if it wins the election. If the two parties happen to endorse the same policies, and spend the same amounts on their campaigns, then party A will capture a total of $\left(\frac{1}{2}+b\right)L$ of the votes. To inject some uncertainty into the outcome of the election, suppose that when party platforms t^A and t^B are chosen, each party regards

b (the relative popularity of party A) as the future realisation of a random variable $\widetilde{b}$. Ex ante, b can be positive or negative, so that even if the platforms converge, each party has a chance to win a majority. Denote by $\varphi(\cdot)$ the distribution of b as perceived by the parties at the time they announce their policies.

Each party sets its policy to maximise its chance of winning a majority, in light of its prior beliefs about the distribution of $\widetilde{b}$. The best that each party can do is to choose its own policy and campaign spending W^P and C^P to maximise this probability. While the number of votes won by each party depends on what the other party does, the linearity of the objective function (4.10) means that the marginal incentive for each party to change its tax platform does not depend on what the other party does. This feature makes solving the model very simple. Nevertheless, in equilibrium party platforms cannot be very different from one another, because they are both constrained by the platform-contingent contributions of the SIG. This is consistent with the observation that the platforms of rival parties tend not to be very dissimilar from one another.

From the number of votes won (4.10), we can obtain the objective function of each political party. For party A, the probability that $s > \frac{1}{2}L$ is maximised when the party adopts the tax platform t^K that maximises

$$G^A = \max_{t^K} \left\{ (1-\alpha) f \left(W^A\right) L + h \left(C^A\right)^{\frac{1}{2}} \right\} \tag{4.11}$$

while for party B, the probability that $(1-s) > \frac{1}{2}L$ is maximised when the party maximises

$$G^B = \max_{t^K} \left\{ (1-\alpha) f \left(W^B\right) L + h \left(C^B\right)^{\frac{1}{2}} \right\} \tag{4.12}$$

Each party maximises a weighted sum of campaign contributions and the welfare of the informed voters. The weight on welfare is greater, the greater is the fraction of informed voters (the larger is $1-\alpha$), and the narrower is the range of their ideological view (the larger is f).

We now consider the behaviour of the special interest group. Denote by $\left(r - t^K\right) K$ the aggregate utility that members of the interest group derive from the policy t; the utility of capital owners is again linear in their income. The SIG knows that party A will win a majority only if the realisation of $\widetilde{b}$ is such that $s > \frac{1}{2}L$. This happens with probability

$\varphi(\Delta)$, where

$$\Delta = G^A - G^B = (1-\alpha) f \left(W^A - W^B\right) L + h \left[\left(C^A\right)^{\frac{1}{2}} - \left(C^B\right)^{\frac{1}{2}}\right] \tag{4.13}$$

The SIG attaches a probability $\varphi(\Delta)$ to the event $t = t^A$, and a probability $1 - \varphi(\Delta)$ to the event $t = t^B$. Hence the objective function of the SIG is:

$$V_L = \varphi(\Delta) \left[\left(r - t^{KA}\right) K\right] + \left[1 - \varphi(\Delta)\right] \left[\left(r - t^{KB}\right) K\right] - C^A - C^B \tag{4.14}$$

The key feature of the political model is that it is effectively the lobby that decides government policy through its campaign contributions. The lobby chooses contributions and hence policy to maximise its welfare V_L, taking as given the two parties' responses to its contributions, while the two parties each choose policy platforms to maximise its vote share, given the platform of the other party and the contribution schedule of the lobby. Because of its first mover advantage and its ability to offer a platform-contingent contribution schedule to each party, the lobby is able to exploit the competition for votes between the two parties to set its own agenda. The solution is a Nash equilibrium in contributions and policies.

If the lobby offers nothing to a party, then the party would support the policy that best served the average informed voter. From the government's budget constraint (4.5), the equilibrium policy would then be:

$$t^{L*} = 0 \qquad t^{K*} = \frac{G}{K} \tag{4.15}$$

That is, in the absence of lobbying activity, policy favours labour and hurts capital. A party will deviate from this policy only if it can get at least as many votes by deviating as it would by implementing this policy. Deviating from this policy in favour of the SIG costs the party some votes from informed voters. Therefore, to induce the party to implement a more favourable policy to itself, the lobby must compensate the party for the loss of votes from informed voters, with a gain in votes from uninformed voters. Hence from equation (4.13), the SIG must offer to party A a contribution of at least

$$C^A \geq \left[\frac{(1-\alpha) f}{h}\right]^2 L^2 \left(W^* - W^A\right)^2 \tag{4.16}$$

Notice that this does not depend on the policy position adopted by party B; this again follows from the linearity of the objective function. Similarly, to induce it to adopt the platform t^B, the lobby must offer party B a contribution of at least

$$C^B \geq \left[\frac{(1-\alpha) f}{h}\right]^2 L^2 \left(W^* - W^B\right)^2 \tag{4.17}$$

The lobby's problem is then to choose t^A, t^B to maximise its objective function (4.14), subject to the constraints (4.16) and (4.17). We assume that the lobby offers each party a contribution that leaves it with exactly the same chance of winning the election as it would be endorsing t^*, so that both constraints hold with equality. This is optimal for the lobby if additional contributions will not substantially change the election outcome; this is what Grossman and Helpman (1996) refer to as influence-seeking behaviour by the lobby: the lobby contributes in order to influence policy platforms but not the outcome of the election.[39]

If both parties do not receive any contributions, then party A would win the election with probability $\varphi(0)$. But since the contribution leaves each party with the same chance of winning the election as without the contribution, then the probability that A wins the election is $\varphi(0)$ regardless of the pair of policies chosen by the SIG. The SIG finds it beneficial to offer contributions to both groups because of the uncertainty over which party will win the election, at the time when contributions are offered.

Appendix 4.A shows the conditions for which the SIG will maximise its objective function by lobbying. If both parties are equally likely to win the election, that is, if $\varphi(0) = \frac{1}{2}$, then for a range of parameter values $b \in \left(-\frac{1}{4}, \frac{1}{4}\right)$, derived in the appendix, the SIG will obtain a higher level of welfare by lobbying than by not lobbying. Substituting for campaign contributions in the lobby's objective using the fact that, with influence-seeking behaviour, the constraints (4.16) and (4.17) hold with equality, we find that the SIG will maximise its welfare by lobbying both parties, provided that neither party is too popular (b is not too large in absolute value).

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[39] Grossman and Helpman (1996) also consider the possibility that the SIG offers more contributions than are required to satisfy the constraints (4.16) and (4.17). They refer to this as an electoral motive for campaign contributions, as this would change the outcome of the election. For simplicity we do not consider this possibility here.

Substituting the contributions into the lobby's objective function using the constraints gives:

$$\begin{aligned} V_L &= \varphi(0)\left[\left(r - t^{KA}\right)K\right] + \left[1 - \varphi(0)\right]\left[\left(r - t^{KB}\right)K\right] \\ &\quad - \left[\frac{(1-\alpha)f}{h}\right]^2 L^2\left[\left(W^* - W^A\right)^2 + \left(W^* - W^B\right)^2\right] \end{aligned} \tag{4.18}$$

The lobby chooses t^{KA} and t^{KB} to maximise the objective function above:

$$t^{KA} = \arg\max_{t^K}\left\{\begin{array}{c} \varphi(0)\left[\left(r - t^K\right)K\right] \\ -\left[\frac{(1-\alpha)f}{h}\right]^2 L^2\left(W^* - W^A\right)^2 \end{array}\right\}. \tag{4.19}$$

$$t^{KB} = \arg\max_{t^K}\left\{\begin{array}{c} \left[1 - \varphi(0)\right]\left[\left(r - t^K\right)K\right] \\ -\left[\frac{(1-\alpha)f}{h}\right]^2 L^2\left(W^* - W^B\right)^2 \end{array}\right\} \tag{4.20}$$

The influence-seeking lobby induces both parties to behave as if they were maximising weighted sums of the collective welfare of interest group members, and the welfare of informed workers. The weight on the welfare of the SIG depends on the probability that the party will win the election, while the weight on the welfare of the informed voters depends on the fraction of voters who are informed, the dispersion of voter preferences across the two parties, and the effectiveness of lobbying activity in influencing the uninformed.

Define $\varphi^A = \varphi(0)$ and $\varphi^B = [1 - \varphi(0)]$. Then the first order condition implies:

$$\begin{aligned} t^{KP} &= t^{K*} - \frac{\varphi^P}{2}\left(\frac{1}{K}\right)\left[\frac{h}{(1-\alpha)f}\right]^2 \qquad P = A, B \\ &= \frac{1}{K}\left\{G - \frac{\varphi^P}{2}\left[\frac{h}{(1-\alpha)f}\right]^2\right\} \end{aligned} \tag{4.21}$$

Therefore, $t^{KP} < t^{K*}$. The tax rate on capital imposed by party P when it receives campaign contributions from the SIG is lower than when the party does not receive any contribution. In order to win the uninformed vote, each party will accept contributions from the SIG, in exchange for policies that favour the SIG and harm the voters. Proposition 4.1 summarises the role of the absolute capital stock on policy:

Proposition 4.1: *All else equal, policies are more favourable to capital the more capital there is in the economy:* $\frac{dt^{KP}}{dK} < 0$ *for* $t^{KP} > 0$. *A party's policy platform is more favourable to capital the more likely it is to win the election (the larger is* φ^P*), the more effective is campaign spending (the larger is* h*), the larger the fraction of uninformed voters (the larger is* α*), and the more dispersed are voter preferences (the smaller is* f*).*

The more effective is campaign spending and the larger is the fraction of uninformed voters, the larger the gain to each party of campaign spending in terms of votes won, hence the more willing are parties to accept contributions from the SIG. The larger the dispersion of voter preferences across the two parties, the less costly in terms of votes lost will be a shift in policy away from the optimal platform for labour, since there are fewer marginal voters who will change their votes in response to a change in platforms.

Lobbying activity by the SIG changes the tax regime from one in which all tax revenue is obtained from capital alone, to one in which tax revenue is obtained from both capital and labour. From the government revenue requirement, if a given fraction of government revenue is obtained from capital taxation, then clearly tax rates can be lower if there is more capital, and still meet the government revenue requirement. In the presence of lobbying activity, the tax rate on capital is lower than in the absence of lobbying activity; political parties offer lower tax rates to the capital SIG in return for campaign contributions.

The tax rate on labour can be obtained by substituting the tax rate on capital back into the government budget constraint:

$$\begin{aligned} t^{LP} &= \frac{G}{L} - t^{KP}\left(\frac{K}{L}\right) \\ &= \frac{\varphi^P}{2}\left(\frac{1}{L}\right)\left[\frac{h}{(1-\alpha)f}\right]^2 > 0 \end{aligned} \tag{4.22}$$

With labour as with capital, the more labour there is in the economy, the lower is the tax rate on labour in equilibrium. With lobbying, the tax rate on labour is positive as opposed to zero without lobbying, as parties sacrifice votes from informed voters by reducing their welfare, for votes from uninformed voters by spending more on their election campaigns. The tax rate on labour is higher the higher the party's probability of winning the election, as this induces larger contributions from the SIG hence shifting the party's platform away from the voters' ideal. The labour tax rate is also higher the more effective is campaign spending, the smaller the fraction of informed voters $(1-\alpha)$, and also the greater the dispersion of voter preferences across parties (the smaller is f), as the greater is this dispersion, the fewer the number of informed voters who will change their vote as a result of a change in the party's platform.

Notice that total tax revenue from labour and capital, $t^{LP}L$ and $t^{KP}K$, are constants that depend on how effective are campaign contributions, but not on the amount of capital or labour in the economy, provided that there are positive amounts of either factor of production. The more effective are campaign contributions (i.e. the larger are α and h), the larger the total tax revenue from labour, and the lower the total tax revenue from capital, as parties put more weight on the welfare of the SIG.

Finally, note also that the SIG does not contribute equally to each party, and hence the policy platforms of both parties do not converge, if the parties are not identical. From the SIG's optimal choice of t^{KA} and t^{KB}, equations (4.19) and (4.20), the party that has the higher probability of winning will place a greater weight on the SIG's welfare. To induce the front-runner to implement a policy more favourable to itself (and hence more harmful to voters), the SIG must (from the contribution functions (4.16) and (4.17)) offer a larger contribution to compensate the party for the loss of votes that this would otherwise imply. This can also be seen more formally by substituting for the welfare levels of labour in the contribution functions (4.16) and (4.17) from the voter welfare functions (4.6) and (4.7) and equilibrium tax rates on labour from equation (4.22):

$$\begin{aligned} C^P &= \left[\frac{(1-\alpha) f}{h}\right]^2 L^2 \left(W^* - W^P\right)^2 \\ &= \left[\frac{(1-\alpha) f}{h}\right]^2 \left(t^{LP} L\right)^2 \\ &= \frac{\left(\varphi^P\right)^2}{4} \left[\frac{h}{(1-\alpha) f}\right]^2 \end{aligned}$$

Therefore, the contribution paid by the SIG to a party depends positively on its probability of winning φ^P and the effectiveness of campaign spending h, and negatively on the share of informed voters $(1-\alpha)$ and the density of voter preferences f. Notice also that the level of contribution is independent of the capital stock, a result which will be useful in the following subsection where we consider the implications of capital mobility.

4.2.3 Capital mobility

Now suppose that we have capital mobility across locations (while labour remains immobile across locations). This is a simplification of the idea that in reality, capital is relatively mobile while labour is relatively immobile.[40] Assume that the two locations are identical except for different endowments of capital and labour. Therefore, if the governments in both locations are lobbied by the capital SIG, the total tax revenue derived from capital and labour are identical, so that any differences in the tax rate on capital between the two locations is due solely to differences in the capital stock. We can therefore drop the locational subscript for the total tax revenue.

Let there be a linear cost of capital mobility, $c(K_M) = \gamma K_M$, where K_M is the amount of capital that moves from one location to the other, so that the cost of moving one unit of capital is γ. Suppose that the cost of capital mobility is small, but nonzero. This is a simple way of formalising the idea that capital is not perfectly free to move between locations. From a technical standpoint, a cost of capital movement is necessary to obtain a unique subgame-perfect Nash equilibrium when absolute capital stocks differ between locations.

Recall that our production functions in the two sectors are $X_1 = x_1(K_1)$, and $X_2 = x_2(L_2)$, for both Home and Foreign. This implies that, with free trade, every point within the Edgeworth Box has factor prices completely equalised across locations, thus allowing us to ignore the impact of changing factor prices on the analysis.

Given the linear specification for mobility costs and the linear technology, if one unit of capital gains by moving, then all units of capital in that location must gain by moving, so that the movement decision can be simplified to whether or not all the capital in a location moves to the other location. More generally, if the FPE set is a subset of the Edgeworth Box, then we can get an interior equilibrium whereby some capital remains in each location. Appendix 4.B sketches the outcome allowing for factor prices to change; this still enables the mechanisms of the model to operate, but the analysis would be complicated by the additional consideration on factor prices. In terms of notation, in this subsection we work exclusively with tax rates on capital, so we suppress the superscripts indicating capital or labour tax rates.

[40] Labour mobility across states in India is very low. From the 1981 census, 95.2 percent of the Indian population was born in the state in which they currently reside; the equivalent number was 95.9 percent in 1991. This compares with the US, where, in 2000, some 8.7 percent of the population did not live in the same state as they did in 1995 (see Franklin (2003)).

The game in the previous subsection may be rewritten to allow for the possibility of capital mobility. Then, the outcome of the previous subsection may be interpreted as a special case of the game where capital is not allowed to move between locations. When we allow capital to move, it moves after policies are announced, but before production takes place, and taxes are paid to the government in the location where capital finally locates. We assume that capital that moves from one location to the other cannot be excluded by the incumbent capital from the benefits of lower tax rates. Lobbies can only lobby the government of the location in which they are initially located.

The timing of the game is now as follows:

(1) In Stage 1, the SIG in each location simultaneously decide whether or not to offer campaign contributions to their own governments.

(2) In Stage 2, campaigns are waged, elections take place, and policies are implemented. Policies are observed by all agents prior to the start of Stage 3.

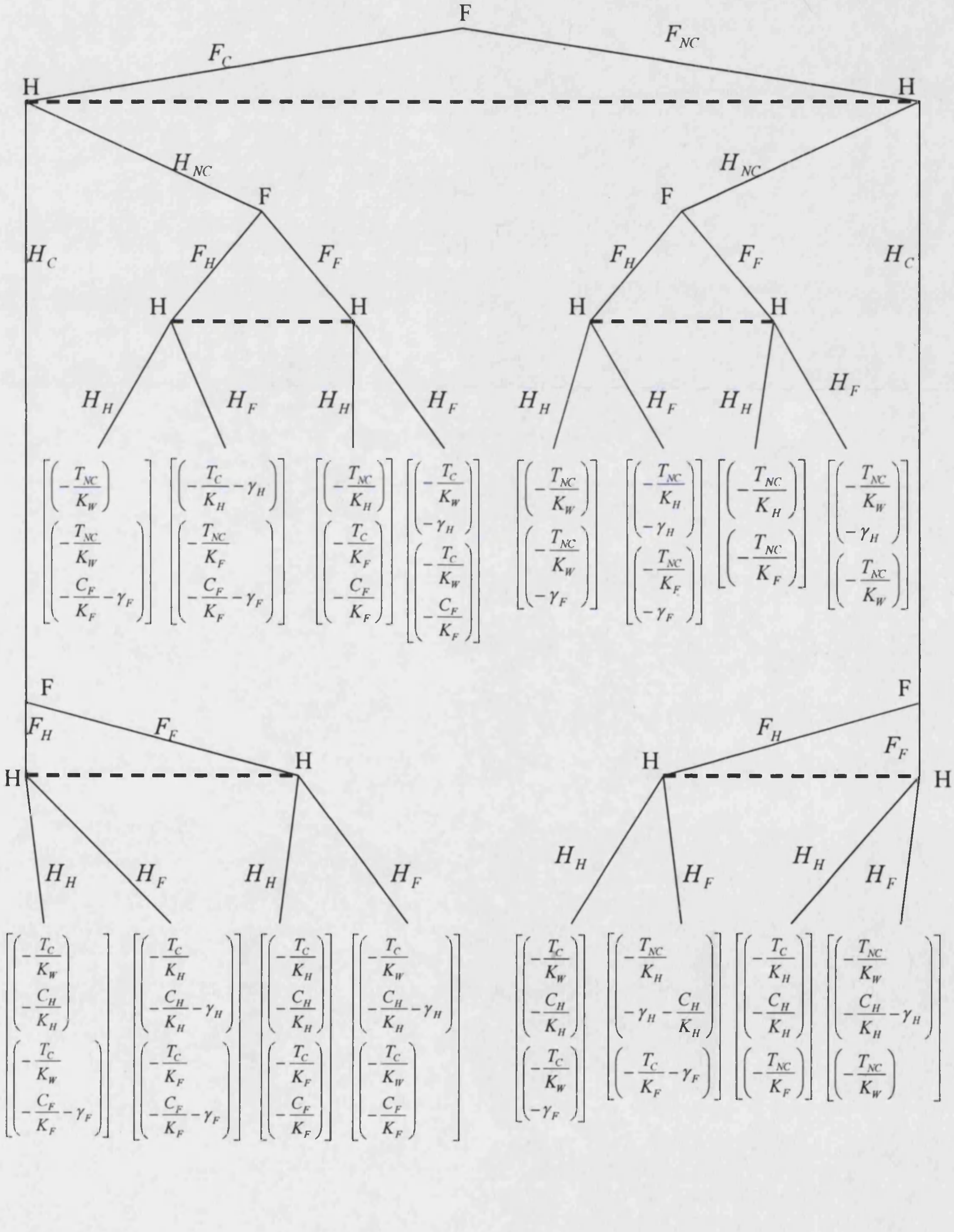
(3) In Stage 3, capital in each location simultaneously decides whether or not to move, production takes place, factors and taxes are paid in their final location.

Figure 4.2 is the extensive form representation of this game. All the action takes place in Stages 1 and 3. The choices faced by the SIGs H and F in Stage 1 are whether to contribute (C) or to not contribute (NC) to the government in their initial locations, having solved in the previous section the optimal contribution level conditional on contributing. The dashed line linking the two nodes of H indicates that the two nodes form a single information set; that is, H does not know which node in the information set has been reached, since the SIGs move simultaneously.

In Stage 3, each SIG decides whether to locate in Home or in Foreign. F_H denotes the decision of all capital in Foreign to move to Home, while F_F denotes the decision of the capital in Foreign to stay in Foreign. Once again the dashed lines linking the nodes of Home indicate that both SIGs move simultaneously.

The payoffs are written first for the Home SIG, then for the Foreign SIG, and represent the impact on the per unit return on capital. Take for example the case when both SIGs contribute, and both locate in Home (the lower left branch of the game tree).

Figure 4.2: Game tree, extensive form.



Recall that each SIG contributes to the government in its initial location, but pays the tax in its final location. Then the payoff to Home's SIG is $\left(-\frac{T_C}{K_W} - \frac{C_H}{K_H}\right)$, while the payoff to Foreign's SIG is $\left(-\frac{T_C}{K_W} - \frac{C_F}{K_F} - \gamma_F\right)$, where T_C is the total tax revenue from capital when the capital SIG offers contributions to the government; recall from the previous subsection that, conditional on the government being lobbied, the total tax revenue from capital is independent of the amount of capital in the economy, and only depends on the parameters of the model (which we assume to be identical in the two countries). $K_W = K_H + K_F$ is the total endowment of capital in the world. Therefore, if this is the outcome of the game, then since Home has contributed and all the capital in the world is in Home, the tax rate on capital is $\frac{T_C}{K_W}$, while the cost of contribution per unit of capital is $\frac{C_H}{K_H}$. For Foreign, it gets the same tax rate as Home since it has moved to Home, it has paid the cost of contributing to its own government, and it has incurred the cost of moving, γ_F.

4.2.4 Equilibrium with capital mobility

The Nash equilibria for each Stage 3 subgame can be seen most clearly if there are no capital mobility costs ($\gamma = 0$). Then, in the subgame where both SIGs have contributed, if Home chooses to stay in Home, then Foreign's best response is to move to Home since the tax on capital is spread over a larger number of units of capital $\left(-\frac{T_C}{K_W} > -\frac{T_C}{K_F}\right)$, while if Foreign decides to move to Home, then Home's best response is to stay at Home for the same reason $\left(-\frac{T_C}{K_W} > -\frac{T_C}{K_H}\right)$. Therefore, for this subgame, the outcome that both SIGs locate in Home (F_H, H_H) is a Nash equilibrium[41]. But there is another Nash equilibrium, since if Home decides to move to Foreign, then Foreign is better off staying in Foreign $\left(-\frac{T_C}{K_W} > -\frac{T_C}{K_F}\right)$, while if Foreign stays in Foreign, then Home's best response is to move to Foreign $\left(-\frac{T_C}{K_W} > -\frac{T_C}{K_H}\right)$. Hence for this subgame, both SIGs locating in Foreign (F_F, H_F) is another Nash equilibrium.

Performing the same exercise for all the remaining Stage 3 subgames yields the following Nash equilibria listed in Table 4.1. Note that these equilibria also hold for positive but small mobility costs. Each of the Nash equilibria has both SIGs locating in

[41] In this case, since all the capital in Foreign has located in Home, to satisfy the government budget constraint in Foreign, the entire tax burden must fall to labour, so that the tax rate on labour is $t^{LF} = \frac{G}{L_F}$.

1	Foreign SIG contributes to the Foreign government, Home SIG contributes to the Home government, Foreign capital moves to Home, and Home capital remains at Home (F_C, H_C, F_H, H_H)
2	Foreign SIG contributes to the Foreign government, Home SIG contributes to the Home government, Foreign capital remains in Foreign, Home capital moves to Foreign (F_C, H_C, F_F, H_F)
3	Foreign SIG contributes to the Foreign government, Home SIG does not contribute, Foreign capital remains in Foreign, Home capital moves to Foreign (F_C, H_{NC}, F_F, H_F)
4	Foreign SIG contributes to the Foreign government, Home SIG does not contribute, Foreign capital moves to Home, Home capital remains in Home (F_C, H_{NC}, F_H, H_H)
5	Foreign SIG does not contribute, Home SIG contributes to the Home government, Foreign capital moves to Home, Home capital remains at Home (F_{NC}, H_C, F_H, H_H)
6	Foreign SIG does not contribute, Home SIG contributes to the Home government, Foreign capital remains in Foreign, Home capital moves to Foreign (F_{NC}, H_C, F_F, H_F)
7	Foreign SIG does not contribute, Home SIG does not contribute, Foreign capital remains in Foreign, Home capital moves to Foreign $(F_{NC}, H_{NC}, F_F, H_F)$
8	Foreign SIG does not contribute, Home SIG does not contribute, Foreign capital moves to Home, Home capital remains in Home $(F_{NC}, H_{NC}, F_H, H_H)$

Table 4.1: Nash equilibria in the game tree in Figure 4.2

the same location, because it is assumed that the relocation costs of capital are sufficiently low relative to the benefit from lower tax rates that they would get if they locate together.

Next, we show which of the above Nash equilibria are subgame perfect. Now it is useful to re-introduce the cost of capital mobility. Note first that, if the movement cost of capital is sufficiently low, that is if $\gamma_H < \frac{T_{NC}-T_C}{K_W}$, the Nash equilibrium 4: (F_C, H_{NC}, F_H, H_H) is dominated by 3: (F_C, H_{NC}, F_F, H_F), in the sense that both Home and Foreign SIGs would prefer the latter outcome to the former. Similarly, if $\gamma_F < \frac{T_{NC}-T_C}{K_W}$, then the Nash equilibrium 6: (F_{NC}, H_C, F_F, H_F) is dominated by 5: (F_{NC}, H_C, F_H, H_H). In the rubric of game theory, the latter Nash equilibrium in each case is the only admissible equilibrium. We assume this to be the case in what follows; this reduces the number of admissible Nash equilibria from 8 to 6.

If Foreign contributes, then Home's best response would be to not contribute, since this response leads to the outcome (F_C, H_{NC}, F_F, H_F), which yields the payoff to Home of $\left(-\frac{T_C}{K_W} - \gamma_H\right)$, which is greater than the possible payoffs if Home contributes, $\left(-\frac{T_C}{K_W} - \frac{C_H}{K_H}\right)$ for outcome (F_C, H_C, F_H, H_H) or $\left(-\frac{T_C}{K_W} - \frac{C_H}{K_H} - \gamma_H\right)$ for outcome (F_C, H_C, F_F, H_F), as long as $\gamma_H < \frac{C_H}{K_H}$. Therefore, provided this condition holds, one subgame perfect equilibrium is (F_C, H_{NC}, F_F, H_F); that is, the Foreign SIG contributes while the Home SIG does not, and the Home SIG moves to Foreign. Intuitively, by not contributing and moving to Foreign, the Home SIG gets the benefit of the Foreign SIG's lobbying for lower taxes on capital, and avoids paying contributions to the Home government.

Doing the same on the other side of the game tree, we find that, provided $\gamma_F < \frac{C_F}{K_F}$, the other subgame perfect outcome is (F_{NC}, H_C, F_H, H_H); that is, the Foreign SIG does not contribute but instead moves to Home, while the Home SIG stays at home and lobbies the Home government for pro-capital policies. If the two locations are identical in every way, there is nothing to distinguish between the two subgame-perfect outcomes; they are symmetric. In fact, as long as the two conditions $\gamma_F < \frac{C_F}{K_F}$ and $\gamma_H < \frac{C_H}{K_H}$ hold, each SIG will prefer a different subgame perfect outcome, so that it is not possible to choose between the two outcomes.

This multiple equilibria outcome of the game appears at first sight to hamper our attempt to draw a prediction from initial endowments of capital to final endowments. However, we can eliminate one of the two equilibria if initial capital stocks are sufficiently different between locations. What we want to do is to derive a set of conditions for which the only subgame perfect outcome of the game is that the location with initially larger capital stock is the one that lobbies its government, and that the SIG from the other location will decide to relocate to the first location. This is equivalent to the set of conditions that will eliminate the second subgame perfect outcome as a possible outcome of the game.

The first step in doing this is to notice that the derivation of the two subgame perfect outcomes depends on the two conditions $\gamma_H < \frac{C_H}{K_H}$ and $\gamma_F < \frac{C_F}{K_F}$. Since the two locations are assumed to be identical apart from their factor endowments, total lobbying costs and per unit movement costs are identical across locations: $C_H = C_F$ and $\gamma_H = \gamma_F$. Therefore, if $K_H > K_F$, then for some values of K_H and K_F, the condition $\gamma_H < \frac{C_H}{K_H}$ is violated, while the other condition $\gamma_F < \frac{C_F}{K_F}$ remains valid.

Because the per unit cost of moving is a constant, while the per unit lobbying cost decreases the more capital there is (recall that total lobbying cost is a constant from the above subsection), the location with more capital will have an absolute and comparative advantage in lobbying. This means that when $\gamma_H > \frac{C_H}{K_H}$ and $\gamma_F < \frac{C_F}{K_F}$, the cost of the Home SIG moving is greater than its cost of lobbying, while the opposite is true for the

Foreign SIG. It follows that, rather than lobbying its own government, the Foreign SIG would prefer to move to Home, while the Home SIG would prefer to stay at Home and lobby the Home government. The unique subgame perfect Nash equilibrium is therefore (F_{NC}, H_C, F_H, H_H); that is, the Home SIG, which has initially more capital, will remain at Home and lobby its government, while the Foreign SIG will not lobby its government but instead will relocate to Home. We now demonstrate more formally that this is indeed the case.

Violation of the condition that $\gamma_H < \frac{C_H}{K_H}$ implies that the two outcomes (F_C, H_{NC}, F_F, H_F) and (F_{NC}, H_C, F_H, H_H) are no longer both subgame perfect outcomes. Now, both SIGs will prefer the outcome (F_{NC}, H_C, F_H, H_H), since for both SIGs, the payoff from this outcome is superior to that of the other outcome: $\left(-\frac{T_C}{K_W} - \frac{C_H}{K_H}\right) > \left(-\frac{T_C}{K_W} - \gamma_H\right)$ for the Home SIG since $\gamma_H > \frac{C_H}{K_H}$, and $\left(-\frac{T_C}{K_W} - \gamma_F\right) > \left(-\frac{T_C}{K_W} - \frac{C_F}{K_F}\right)$ for the Foreign SIG since $\gamma_F < \frac{C_F}{K_F}$. Therefore, the outcome (F_{NC}, H_C, F_H, H_H) is now the only admissible subgame perfect outcome of the game as it dominates the other candidate outcome.

That the cost of capital movement is neither too small nor too large is crucial for this result. If it is too expensive for capital to move between locations, it will never be optimal for capital to move. On the other hand, if capital mobility is costless, then both SIGs would be indifferent between the two subgame-perfect Nash equilibria.

Intuitively, it is simple to see why we get this outcome. The SIGs face a choice of paying the contribution and getting lower tax rates, or incurring a mobility cost to move to the other location to free ride on the other SIG's contribution (provided of course that the other SIG does in fact contribute). But since the previous subsection has shown that the total cost of contributing is independent of the capital stock, the cost of contribution per unit of capital decreases the more capital there is in the economy, while the per unit mobility cost is constant. Therefore, the larger is the capital stock in a location relative to the other location, the less willing is the SIG in the first location to move. Given this unwillingness to move, the SIG in the other location would then find it always beneficial to move.

To see how this mechanism can lead to a reversal of initial comparative advantage, suppose that initially Home has absolutely more capital than Foreign, $K_H > K_F$, but that

Home is relatively capital-scarce compared to Foreign, $(\frac{K}{L})_H < (\frac{K}{L})_F$. Then, initially, Home would have had a comparative advantage in the labour-intensive good. But since capital moves from Foreign to Home, Home will become capital-abundant relative to Foreign, and so will have a comparative advantage in the capital-intensive good.

As noted in the introduction, in this model, absolute factor endowments influence comparative advantage indirectly. Absolute factor endowments influence tax rates on capital, which provides capital with an incentive to relocate to the location which gives the higher (post-policy) rate of return. This changes the locations' relative factor endowments, causing a change in its comparative advantage. What the model does not consider is that it is possible for policies to influence locations' comparative advantage directly, through factor prices. The reason this is the case, is that we focus on the case where factor prices are equalised, and that government policy does not affect firms' profit-maximising decisions (see the brief discussion in subsection 4.2.1 above). If we relax these assumptions, the model would yield a direct impact on locations' comparative advantage.

To conclude this section on theory, we briefly summarise the two main theoretical predictions. The first main theoretical prediction, from Proposition 4.1, is that larger absolute capital stock is related to more favourable policy towards capital. This is the case whether or not we allow for the possibility of capital mobility across locations. The second main theoretical prediction, from the extension of the model to allow for capital mobility, is that differences in policy stance across locations, by providing capital with an incentive to move between locations, will lead to a divergence in both absolute and *relative* factor endowments between the two locations, and hence to different industrial structures across locations. We test both these predictions in the next section.

4.3 Empirical evidence

In this section, we consider evidence from a state-time panel dataset from India on the two predictions of our theoretical model: the relationship between factor endowments and policies, and the impact of policy on industrial structure. The advantages of using within-country data are: first, that other sources of cross-location heterogeneity in government policies would be smaller within a country than across countries, and second, that capital mobility, crucial for the second theoretical prediction, is higher within than across countries. However, the model could in principle also be tested using cross-country data.

4.3.1 Campaign contributions in India

Our theoretical model is based on the role of campaign contributions in influencing the policy stance of governments. One of our tasks must therefore be to show that campaign contributions do in fact play a significant role in elections in India. Here, we present a brief history of the laws and reality of campaign contributions in India in the last 50 years[42].

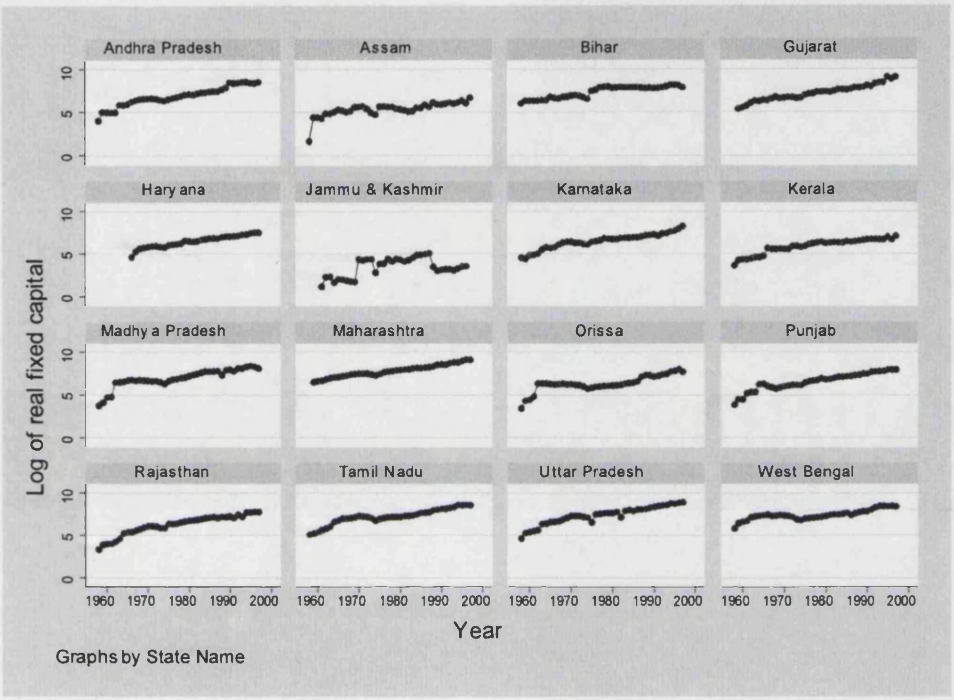
Political parties in India do not receive direct state subsidies. They do receive some subsidised television time and other indirect benefits, such as office space in the capital, but Indian parties raise most of their funds from corporate contributions. There is also evidence that corruption is high (see e.g. Das (2002); in 2002 Transparency International's Corruption Perceptions Index ranked India joint 71st out of 102 countries in terms of the level of corruption, where a rank of 1 is the lowest level of corruption and 102 the highest level of corruption).

From 1951 to 1969, most private donations to political parties were legal, but public-sector firms were not allowed to make political contributions. Contributions were not subject to limits, but campaign spending itself was limited. In 1969, corporate contributions were banned. Then, in 1975, the Indian Supreme Court ruled that political expenditures not authorised by a candidate do not count towards that candidate's spending limits. As a result of these events, political finance moved underground. When corporate contributions became legal again in 1985, most parties and their corporate benefactors had become used to the underground system of unreported cash or in-kind contributions.

Since 1990, campaign contributions have continued to increase, while expenditure limits remain unrealistically low. But since unauthorised expenditures do not count to-

[42] The following exposition is based on the report on The Democracy Forum for East Asia's working conference "Political Finance and Democracy in East Asia: The Use and Abuse of Money in Campaigns and Elections", 28-30 June 2001. The report is available online at http://www.ned.org/asia/june01/introduction.html.

Figure 4.3: Log of real fixed capital



ward candidate limits, such expenditures technically do not violate the law. In effect, there are no limits either on contributions or expenditures. Not only do researchers not have reliable data on campaign expenditures; the parties themselves may not fully know what was expended in the campaigns. Consistent with the model, campaign contributions play an important role in Indian politics. Although we cannot observe campaign contributions, we examine the model's prediction of a direct link between capital stocks and policies.

4.3.2 Data and methods

The test of our first theoretical prediction on the determinants of government policy is performed for the period 1959-1997, using data on the 16 largest states in India, which account for about 97% of the total population, while the test of our second theoretical prediction on industrial structure is based on a subset of this period, from 1980 to 1997, as this second test exploits information on patterns of specialisation across more than 100 individual manufacturing industries. The data appendix lists the data sources. Real fixed capital stocks across Indian states are shown in Figure 4.3, which shows the disparity in capital accumulation, with no indication that states with initially less capital are catching up with those that have more capital. We use three alternative estimation methods. First, using OLS, we estimate regressions of the form:

$$LR_{st} = \alpha_s + \beta_t + \phi_1 \ln(K_{st}) + \phi_2 \ln(L_{st}) + \delta x_{st} + \varepsilon_{st} \tag{4.23}$$

where LR_{st} is the measure of labour regulation in state s in year t, as discussed above in section 4.2.1. As discussed there, pro-worker amendments to the Industrial Disputes Act are coded as +1, while pro-capital amendments are coded as -1. This fits in nicely with the theoretical model, as a lower tax rate on capital is a pro-capital policy.[43] $\ln(K_{st})$ and $\ln(L_{st})$ are the log of capital stock and population in state s in year t.

α_s are the state dummies, which pick up all inter-state differences which are constant over time, and β_t are year dummies, which control for common shocks. The inclusion of state and year dummies in all our regressions means that identification of the coefficients comes from the within-state relationship between changes in absolute capital endowments and changes in labour regulation.

The x_{st} are other exogenous variables. One problem which we face in adding additional controls on the RHS of the equation is that most potential controls are themselves endogenous. Therefore we constrain ourselves to two control variables: the political history of states and the per capita state domestic product. Political histories capture the idea that different political parties may have different preferences toward labour and capital. These histories are driven by many factors, including ideology, religion and ethnic mix. The use of state domestic product as a control variable captures the idea that if voter preferences change with income levels, then policymakers may change their policies in response. Besley and Burgess (2004) show that labour regulation has only weak effects on aggregate GDP, although it has large effects on registered manufacturing. Equation (4.23) seeks to uncover the impact of capital endowments on the policy stance of the state government.

[43] The use of labour regulation as the dependent variable in the regression means that we assume that there are no reinforcing or offsetting contemporaneous changes in states' capital legislation.

According to our model, the capital stock may be an endogenous variable. There are two possible effects of labour regulation on capital stock. First, if a state enacts more pro-worker legislation, capital could leave the state, thus inducing a positive correlation between capital stock and pro-employer regulation. On the other hand, it may also be the case that, faced with more pro-worker legislation, firms decide to switch to more capital-intensive techniques of production, in which case there would be a negative correlation between capital stock and pro-employer regulation. Therefore, we follow up the OLS regression with an instrumental-variables regression. The direction of any difference between the OLS and IV estimates of the impact of capital stock on labour regulation can indicate which of these two possible effects dominates.

We use two instruments: the log of total bank credit and the log of installed electricity generating capacity. These variables capture the impact of financial services and electrical power on the location of capital. Bank credit and electricity generating capacity were effectively determined by the central government, through the Banking Regulation Act of 1949, the Banking Companies (Acquisitions and Transfer of Undertakings) Act of 1969, and the Industrial Policy Resolution of 1956, while labour regulation was determined by state governments. In the Banking Regulation Act of 1949, new bank branches require licenses from the central bank of India. This gave the central bank control over the location of bank branches. The Banking Companies Act of 1969 nationalised the 14 largest commercial banks in India, under the direct control of the Indian central bank. The objective of nationalisation was to formally involve the banks in improving financial provision in financially backward regions, by setting up new branches in unbanked locations (areas that did not have any commercial bank branches). The objective of reducing regional disparities was also an important part of the Industrial Policy Resolution of 1956. In this resolution, electricity generation was placed under the exclusive responsibility of the state, and there was an objective to improve provision of electrical power, water supply and transport facilities in areas that were lagging behind industrially, to encourage industrial development in these areas.

For a set of instruments to be valid, the instruments must be both highly correlated with the instrumented variable(s), but uncorrelated with the errors. The availability of bank credit in a state makes it easier for firms to exploit profitable opportunities by lowering the cost of installing new capital, while electrical power is essential for the productive use of modern industrial machinery, but is difficult and expensive to transmit across long distances. Both instruments should therefore be highly correlated with the instrumented variable; we document that this is indeed the case in subsection 4.3.4 below. At the same time, bank credit or electrical generating capacity should be uncorrelated with the error term, since as noted above, these instruments are determined by central government policy, while labour regulation is determined by state governments.[44]

We can also perform some tests for instrument validity. Because we have more instruments than instrumented variables, the model is overidentified. The overidentifying restrictions require that the extra instruments should also be uncorrelated with the errors. We can use a Sargan (1958) or Hansen (1982) test to test for the validity of these restrictions. The test statistic is the criterion function of the IV model[45], divided by the estimate of the error variance of the model, which, under the null hypothesis that the instruments are uncorrelated with the errors, is distributed as a χ^2 with $l - k$ degrees of freedom (where l is the number of instruments, k is the number of regressors). The test assumes that at least one instrument is valid (i.e. orthogonal to the error term), and tests whether the additional instruments satisfy the same assumption of orthogonality with respect to the error term. This however limits the effectiveness of the test, as our two instruments are highly correlated with one another, implying that the test's approach of assuming the orthogonality of one instrument, and testing for the orthogonality of the other instrument, is difficult to justify.

Because the LHS variable in our regression, labour regulation, has characteristics of a discrete dependent variable, running regression (4.23) using OLS implies running a linear probability model. As Maddala (1983) for example points out, the linear probability model is heteroskedastic, and may give unreasonable estimated probabilities of observing certain outcomes (for example, negative probabilities, or probabilities exceeding 1), since OLS does not constrain the predicted value.

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[44] However, there remains the possibility that state governments that are more sympathetic to capital may lobby the central government for a more favourable allocation of electricity generating capacity and banking services. If this is the case, the exclusion restrictions on the instruments would not be satisfied, as electicity generating capacity and bank credit will be influenced by state governments. This possibility should be kept in mind when reviewing the following results.

[45] The criterion function is defined as $Q(\beta, y) = (y - X\beta)^{\top} P_W (y - X\beta)$ where P_W is the orthogonal projection matrix of the instruments W: $P_W = W\left(W^{\top}W\right)^{-1}W^{\top}$. See Davidson and MacKinnon (2004) p. 321.

Therefore, as a separate robustness check, we also perform the regression using ordered logit. This directly addresses the issue of constraining the predicted value, and, with the use of heteroskedastic-robust standard errors, also deals with the issue of heteroskedasticity. The estimation method is maximum likelihood, which raises the issue of the appropriate functional form for the probability function of the discrete dependent variable, as the desirable properties of maximum likelihood are dependent on the distributional assumptions of the likelihood function. The two main alternative functional forms are the standard normal (in which case we get a probit model), and a logistic distribution (from which we get a logit model). If the true model is a probit and we maximise the likelihood function associated with a logit, the estimates will be inconsistent. However, we do not have any priors about the preferred functional form of the probability function, and using either ordered logit or ordered probit gives qualitatively similar results.[46] [47]

4.3.3 The impact of factor endowments on policy in India

Table 4.2 presents the results of our regressions. For each specification we report IV results next to the OLS results, all with heteroskedastic-robust standard errors.

Columns (1) and (2) are the baseline specifications, simply regressing labour regulation on capital endowment, population, and state and year dummies. We find that, using either estimation method, controlling for population, larger capital stocks are associated with lower values of the policy variable; that is, larger capital stocks imply more pro-capital policies. Greater population is associated with less pro-capital policy. Taken together, these results support the prediction of our theoretical model, which is that larger absolute capital stocks are associated with more favourable policies toward capital, while a larger population implies more favourable policies toward labour.

Comparing the results in columns (1) and (2), we find that the coefficient on capital stock is more negative using IV than OLS; this is also the case in the other specifications

[46] The results are so similar between the ordered logit and ordered probit models that we are unable to discriminate between the two models using the test that twice the difference between the two log-likelihood functions is distributed $\chi^2(1)$ (see Johnston and DiNardo (1997) p. 430).

[47] The results are also robust to the number of categories used; in Table 4.4 below, we use each discrete value as one category. Dividing the dependent variable into three categories, for negative, zero and positive values, gives the same qualitative results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable				Labour regulation				
	IV	OLS	IV	OLS	IV	OLS	IV	OLS
Log of real fixed capital	-1.891	-0.391	-2.002	-0.358	-1.478	-0.192	-1.509	-0.172
	(5.92)**	(5.21)**	(5.48)**	(4.73)**	(6.11)**	(3.15)**	(5.77)**	(2.70)**
	[-2.299]	[-0.475]	[-2.376]	[-0.425]	[-1.797]	[-0.233]	[-1.791]	[-0.204]
Log of population	6.360	4.692	7.313	4.775	9.737	9.413	10.551	9.863
	(6.75)**	(7.62)**	(7.24)**	(7.90)**	(6.31)**	(9.14)**	(6.82)**	(9.60)**
	[4.420]	[3.260]	[5.051]	[3.298]	[6.767]	[6.541]	[7.287]	[6.812]
Janata majority					-0.167	-0.377	-0.158	-0.388
					(1.99)*	(8.91)**	(1.85)+	(8.62)**
					[-0.409]	[-0.925]	[-0.388]	[-0.951]
Hindu majority					-0.233	-0.485	-0.232	-0.498
					(2.25)*	(8.36)**	(2.20)*	(8.28)**
					[-0.156]	[-0.324]	[-0.155]	[-0.333]
Hard left majority					-0.012	-0.193	0.003	-0.200
					(0.15)	(4.74)**	(0.04)	(4.60)**
					[-0.040]	[-0.661]	[0.012]	[-0.686]
Regional majority					-0.076	-0.288	-0.071	-0.298
					(1.00)	(7.55)**	(0.91)	(7.26)**
					[-0.385]	[-1.450]	[-0.355]	[-1.501]
Congress majority					-0.076	-0.280	-0.065	-0.290
					(0.95)	(6.93)**	(0.80)	(6.72)**
					[-0.631]	[-2.335]	[-0.529]	[-2.353]
Log of real net state			0.978	-0.300			0.679	-0.052
domestic product p/c			(1.96)+	(1.06)			(1.62)	(0.21)
			[0.338]	[-0.103]			[0.234]	[-0.018]
State dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	605	605	592	592	605	605	592	592
Hansen test	1.39		1.18		0.48		0.27	
Prob (Hansen)>chi2	0.24		0.28		0.49		0.6	
Test capital+population=0	21.04	51.82	28.91	57.31	25.75	82.45	31.04	91.92
Prob>F	0	0	0	0	0	0	0	0
R-squared		0.72		0.73		0.8		0.81
C test	41.48		41.8		86.11		82.1	
Prob (C)>chi2	0		0		0		0	

Notes: Heteroskedastic-robust t statistics in parentheses, and standardised beta coefficients in square brackets. The dependent variable is a cumulative measure of amendments to the Industrial Disputes Act, coded as -1 if it is pro-capital, 0 if it is neutral, and +1 if it is pro-labour. + significant at 10%; * significant at 5%; ** significant at 1%. In the IV regression, fixed capital is assumed to be endogenous, and is instrumented using total bank credit and installed electricity generating capacity. The number of observations varies across specifications because not all variables are available for all observations. Using the same number of observations for all specifications does not change the results. Congress, hard left, Janata, Hindu and regional majority are counts of the number of years for which these political groupings held a majority of the seats in the state legislatures. The Hansen test is the test for overidentification. The C test is the test for whether the capital stock variable is orthogonal to the error term, thus providing a test for the endogeneity of capital stock.
The test that capital+population=0 is the test that the coefficients on capital and labour are the same, i.e. only the capital-labour ratio matters. A rejection of the null hypothesis implies that absolute capital and labour stocks play a role beyond the capital-labour ratio. See the Data Appendix for details on the sources and construction of the variables.

Table 4.2: IV and OLS results for the measure of labour regulation.

in Table 4.2. This may be interpreted as a positive impact of the measure of labour regulation on capital stock. From the discussion in subsection 4.3.2, this finding is consistent with the argument that more pro-labour policy encourages firms to switch towards more capital-intensive techniques. The remaining columns in Table 4.2 control for other possible factors that might influence policy. However, the results on capital and population are robust to our alternative specifications.

Columns (3) and (4) control for state domestic product (SGDP) per capita. This has no significant impact under OLS, but is significant at the 10 percent level under IV. The sign of the coefficient indicates that the greater the state domestic product per capita, the less pro-capital is policy. The coefficients on capital and population are only marginally affected and remain highly significant. While SGDP may be endogenously determined by labour regulation, evidence from Besley and Burgess (2004) suggest that labour regulation has no significant impact on SGDP. However, SGDP is highly correlated with capital stock (correlation in excess of 0.83), which may account for the non-significance of SGDP under OLS, due to multicollinearity.

Columns (5) and (6) control for the political history of the states. The identity of the ruling party in a state clearly has great influence on the policy stance. Using IV, states with more years under a Janata party or a Hindu party, have significantly more pro-capital policies than states under the rule of other parties. Using OLS, more years spent under the rule of any party leads to more pro-capital policies, even though we have controlled for year fixed effects. This large difference between the IV and OLS results suggest that the endogeneity bias that affects all parameter estimates is very strong, leading us to prefer the IV to the OLS estimates. Finally, columns (7) and (8) include all the controls, which does not change any of the previous results.

4.3.4 Effectiveness of using Instrumental Variables

In this subsection we report additional results which lend support to our argument that our instrumental variables are appropriate. Table 4.3 presents the first stage results for the IV estimation, and the reduced form for the main specification (4.23), both with heterokedastic-robust standard errors. These are OLS regressions of the log of fixed capital and labour regulation, on the full set of exogenous variables.

First, consider column (1), the first stage regression for fixed capital. Controlling for all other exogenous variables in the main regression, total bank credit and installed electricity generating capacity have highly significant effects. The more bank credit or electricity generating capacity there is in a state, the greater the amount of fixed capital, which agrees with our intuition. As noted above, increased provision of bank credit or electricity generating capacity makes it more attractive to invest in capital equipment.

Column (1) of Table 4.3 also reports the F-test of the joint significance of the excluded exogenous variables in the first-stage regression. We find that the instruments are highly jointly significant, and therefore play an important role in determining the stock of fixed capital. This provides evidence of the power of the instruments in the first-stage regression, and shows that the instruments we have chosen do in fact have important influences on the instrumented variable.

In column (2), in the reduced form regression, both the instruments have strong direct impacts on labour regulation. Greater bank credit and installed electricity generating capacity are associated with more pro-capital policy. Also, as in Table 4.2, longer political histories tend to be associated with more pro-capital policy.

Since we have more instruments than instrumented variables, we can perform a Hansen (1982) test of overidentifying restrictions. The results are in Table 4.2. We find that the Hansen test passes comfortably in all specifications.

To test for whether capital stock is orthogonal to the error term, and hence whether IV is required, we perform a C test of orthogonality (see Hayashi (2000) pp. 218-221 and 232-234, or Baum, Schaffer and Stillman (2003)). The C statistic is calculated as the difference between the Hansen statistics of the efficient regression (OLS) and the inefficient but consistent regression (IV), where the estimate of the error variance from the OLS regression is used to calculate the Hansen statistic for the IV regression as well. This ensures that the C statistic is always positive. The C statistic is distributed as χ^2 with 1 degree of freedom (equal to the number of potential endogenous variables being tested), and the null hypothesis is that the variable to be tested is orthogonal to the error term.

Dependent variable	(1) Log of fixed capital	(2) Labour regulation
Log of bank credit	0.406	-0.644
	(5.97)**	(8.03)**
Log of installed electricity generating capacity	0.202	-0.258
	(3.39)**	(3.38)**
Log of population	-0.55	11.295
	(0.76)	(12.58)**
Log of net state domestic product p/c	0.321	0.187
	(1.68)	(0.82)
Janata majority	0.207	-0.476
	(6.59)**	(9.47)**
Hindu majority	0.236	-0.591
	(6.63)**	(9.55)**
Hard left majority	0.213	-0.324
	(6.88)**	(6.77)**
Regional majority	0.213	-0.396
	(7.04)**	(8.78)**
Congress majority	0.212	-0.39
	(6.88)**	(8.13)**
State dummies	Yes	Yes
Year dummies	Yes	Yes
Observations	592	592
R-squared	0.98	0.84
F-test of excluded variables	29.63	59.2
Prob>F	0	0

Notes: Heteroskedastic-robust t statistics in parentheses. * significant at 5%; ** significant at 1%. Column (1) is the first stage regression of the IV regression in table 4.1. Column (2) is the reduced form regression. The F-test of excluded variables is a test of the joint significance of the instruments included in the first stage regression but excluded in the second stage regression (log of installed electricity generating capacity, and log of bank credit). See the Data Appendix for details on the sources and construction of the variables.

Table 4.3: First stage and reduced-form regressions.

The results are in Table 4.2. The null hypothesis that capital stock is orthogonal to the error term under an OLS regression, is rejected in all specifications. This is not surprising, as we see large differences in the coefficient estimates between OLS and IV, which strongly suggests a correlation between one or more explanatory variables with the error term leading to a bias in all the OLS estimates.

4.3.5 Robustness

One possible concern of our results is that the capital stock variable in Table 4.2 may be capturing the impact of capital-labour ratio rather than absolute capital stock. If instead of running equation (4.23), we replace capital stock and population by the capital-labour ratio, this is equivalent to running equation (4.23) with the constraint that the coefficients on capital and labour sum to zero:

$$\begin{aligned} LR_{st} &= \alpha_s + \beta_t + \phi_3 \ln\left(\frac{K_{st}}{L_{st}}\right) + \delta x_{st} + \varepsilon_{st} \\ &= \alpha_s + \beta_t + \phi_3 \ln\left(K_{st}\right) - \phi_3 \ln\left(L_{st}\right) + \delta x_{st} + \varepsilon_{st} \end{aligned} \tag{4.24}$$

Therefore, testing if the coefficients on capital and labour in equation (4.23) sum to zero is a test of this constraint. A significant test statistic would indicate that the coefficients do not sum to zero, and therefore that there is additional information from separating the effects of capital and labour. Table 4.2 reports the test statistic, which is always highly significant in every specification, thus supporting our claim that the impact of capital stock on policy is at least partly due to absolute capital rather than relative capital-labour ratios.

While the coefficients of interest are statistically significant, there is the question of how important they are. To explore this, we report standardised or beta coefficients in square brackets in Table 4.2. These are the coefficients that would have been obtained if all the variables were standardised to have mean 0 and a standard deviation of 1. Under the consistent IV regressions, the variables that have the largest beta coefficients are fixed capital and population. The beta coefficient for fixed capital takes values from 1.7 to 2.4; that is, a 1 standard deviation increase in capital stock reduces the measure of labour regulation by 1.7 to 2.4 standard deviations. Population has even larger beta coefficients, ranging from 4.4 to 7.3 under IV. We can therefore conclude that both capital stock and population have significant and large effects on labour regulation.

Table 4.4 presents the results of the ordered logit regressions. Column (1) is the baseline regression, with fixed capital and population on the RHS, heteroskedastic-robust standard errors, and state and time dummies. Both capital and population are significant at the 1 percent level, and are signed as in the OLS regression: more fixed capital is associated with pro-capital policies, while more population is associated with pro-labour policies.

Column (2) adds state domestic product per capita, which has no significant impact on policy. Political histories (column (3)) have the same impact as they do under OLS: longer political histories are associated with more pro-capital policy. The coefficients on absolute capital stock and population remain significant at the 5 percent level.

	(1)	(2)	(3)	(4)
Estimation method		Ordered logit		
Dependent variable		Labour regulation		
Log of fixed capital	-3.384	-3.384	-1.442	-1.442
	(6.34)**	(6.17)**	(2.18)*	(2.17)*
Log of population	37.224	37.221	63.776	64.888
	(6.83)**	(6.71)**	(6.89)**	(6.83)**
Log of net state domestic product		-0.007		1.788
p/c		(0.00)		(0.75)
Janata majority			-14.893	-12.908
			(16.62)**	(13.93)**
Hindu majority			-15.707	-13.732
			(17.37)**	(14.67)**
Hard left majority			-14.054	-12.076
			(16.21)**	(13.43)**
Regional majority			-14.415	-12.455
			(16.30)**	(13.54)**
Congress majority			-14.273	-12.301
			(16.55)**	(13.75)**
State dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Observations	600	600	600	600

Notes: Heteroskedastic-robust z statistics in parentheses. * significant at 5%; ** significant at 1%. The estimation method is ordered logit. The dependent variable is a cumulative measure of amendments to the Industrial Disputes Act, coded as -1 if it is pro-capital, 0 if it is neutral, and +1 if it is pro-labour. Congress, hard left, Janata, Hindu and regional majority are counts of the number of years for which these political groupings held a majority of the seats in the state legislatures. See the Data Appendix for details on the sources and construction of the variables.

Table 4.4: Ordered logit results for labour regulation.

Finally, column (4) includes all the controls, which does not change the results from column (3). Overall, the results of the ordered logit regression serve to confirm the results of OLS and IV, which is that absolute stocks of fixed capital are related to more favourable policies toward capital.

4.3.6 Industrial specialisation in India, 1980-1997

To test the second main prediction of the model, we make use of more detailed data at the 3-digit-industry-state level, for which data is available for over 100 3-digit industries between 1980 and 1997. The prediction of the model which we want to test is the following: the greater is the difference in policies across states, the greater will be the difference in their industrial structure. We can test this proposition using a simple formulation adapted from Bernard and Schott (2002) (see also Bernard, Redding, Schott and Simpson (2003)). In these papers, the following regression equation is used, in a different context, to test for the presence of multiple cones of specialisation in the Heckscher-Ohlin model.

We run the following regression:

$$I_{rs} = \lambda_0 + \lambda_1 |\eta_{rs}| + \lambda_2 I_r + \lambda_3 I_s + \lambda_4 |x_{rs}| + v_{rs} \tag{4.25}$$

The dependent variable I_{rs} is the number of industries common to both states r and s, and $|\eta_{rs}|$ are the absolute differences in the measure of labour regulation between states r and s. I_r and I_s are the number of industries in states r and s; states with more industries are, other things equal, likely to have more industries in common. Therefore, while industrial structure is measured using industry-state-time data, the regression is run using state-time data.

There is, as in the case of our first estimated equation (4.23), a potential concern about reverse causality in equation (4.25). It may be the case that different industrial structures across states drives state governments to have different policy stances towards labour and capital. As a robustness check, we also run the regression with a 1-period-lagged labour regulation instead of current labour regulation. Because we include state and time fixed effects, identification of the parameters comes from the relationship between changes in labour regulation and changes in industrial structure within states. The state fixed effects control for time invariant considerations that affect both labour regulation and industrial structure, while the time fixed effects control for common shocks over time.

$|x_{rs}|$ represents other variables which take the form of absolute differences across states. The controls we include are absolute differences in the land-labour ratio (which controls for exogenous, geographically immobile factor endowments which may have an impact on industrial structure), and per capita state domestic product (SGDP). Per capita SGDP captures possible differences in demand across states based on income levels; if preferences are non-homothetic, states with higher per capita SGDP may demand different goods than states with lower per capita SGDP. If it is costly to ship goods between states, then we may expect states to specialise in industries with greater local demand.

The basic idea in equation (4.25) is that the larger is the value of $|\eta_{rs}|$, the more different are policies and hence factor endowments across states, and therefore the fewer industries the two states should have in common. Therefore we expect λ_1 to be negative. We include state and year dummies in each regression.

Dependent variable	(1)	(2)	(3)	(4)
	Number of industries common to states r and s			
Absolute difference in current labour regulation	-0.501	-0.452		
	(3.08)**	(2.84)**		
Absolute difference in lagged labour regulation			-0.475	-0.424
			(2.89)**	(2.64)**
Total number of industries, reporting state	0.512	0.514	0.526	0.526
	(10.66)**	(10.73)**	(10.04)**	(10.08)**
Total number of industries, partner state	0.661	0.661	0.674	0.673
	(19.93)**	(19.73)**	(19.22)**	(18.94)**
Absolute difference in land labour ratio		0.37		0.442
		(0.25)		(0.29)
Absolute difference in real per capita net state domestic product		-0.217		-0.227
		(5.42)**		(5.72)**
Constant	-39.991	-63.227	-43.676	-46.72
	(5.24)**	(32.65)**	(5.30)**	(9.47)**
State dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Observations	2160	2145	2040	2025
R-squared	0.95	0.95	0.95	0.95

Notes: Heteroskedastic-robust t statistics in parentheses. * significant at 5%; ** significant at 1%. The number of observations is smaller in column (2) as data for state domestic product is missing for Jammu and Kashmir in 1997, and smaller still for columns (3) and (4) due to the lagged labour regulation used. Using the same number of observations for all specifications does not change the results. The dependent variable is the number of 3-digit industries common to any two states r and s. See the Data Appendix for details on the sources and construction of the variables.

Table 4.5: Industry overlap and labour regulation.

Table 4.5 which presents the results with heteroskedastic-robust standard errors, shows that our expectations are confirmed. Column (1) is the basic specification following equation (4.25). All coefficients are highly significant and their signs are consistent with our priors. The absolute difference in labour regulation has a strong negative impact on the number of common industries in the two states, while the total number of industries in each state have very strong positive effects.

In column (2), we control for the absolute difference in the relatively immobile land-labour ratio across states, and the absolute difference in per capita net state domestic product between states. The difference in the land-labour ratio has no significant impact on the number of industries in common, but larger differences in per capita incomes are associated with more different industrial structures. The coefficient on our variable of interest, differences in labour regulation, remains almost unchanged and highly significant; the greater the difference in labour regulation across states, the fewer the industries they have in common.

Columns (3) and (4) report the results of the regression when we use the lagged value of labour regulation instead of present labour regulation, to overcome simultaneity issues. The results are almost identical to those in columns (1) and (2); differences in labour regulation are still negatively and significantly related to similarity in industrial structure. This lends support to our claim that differences in labour regulation lead to differences in industrial structure.

4.4 Conclusions

The main contribution of this chapter is to develop and test empirically a model of electoral competition and campaign contributions that has implications for the structure of economic activity. The model makes two main theoretical predictions. First, locations that have large absolute levels of capital stock tend to implement policies which are more favourable to capital. This prediction is found to hold true across states in India in the period 1959-1997, even after controlling for various other factors that could influence the policy stance. To overcome possible endogeneity issues, in addition to OLS, we use two-stage-least-squares as an alternative method of estimation. A second prediction of the model is that capital tends to flow into locations that already have more absolute levels of capital than their trading partners, and so locations with less similar policies toward capital (due to initial differences in absolute capital endowments) tend to have more different relative factor endowments and therefore specialise in different bundles of goods. This second prediction is also confirmed in the data.

While the predictions of the theoretical model are in accord with the empirical evidence, there are several extensions that can be pursued to enhance our understanding of the key issues. One possible starting point would be to take the tax interpretation of the model, and consider further the role of informed and uninformed voters, the effectiveness of campaign spending and the range of voters' ideological views (corresponding to the parameters $1-\alpha$, α, h and f in the model). For example, as noted in the introduction, evidence across OECD countries has been that capital tax rates have declined over the last 30 years, at the same time as capital mobility across countries has increased. To what extent this is simply the outcome of tax competition between countries for internationally mobile capital, and to what extent it reflects trends in domestic politics, is a topic worth pursuing in future research.

Our results have broader implications for the process of policy formation. Most importantly, the financing of election campaigns through contributions from special interest groups means that policymakers are effectively captured by the special interest group, and the larger is the interest group, the more favourable will policy be towards it. Locations with initially lower capital stock may therefore have difficulties in attracting inward capital flows. However, it is not necessarily the case that small locations are worse off in the presence of capital mobility. The welfare implications for the different locations depends on the extent of repatriation of income from capital abroad.

4.A Conditions for which lobbying enhances the welfare of the SIG

In this appendix, we show the conditions for which the SIG prefers to lobby than not lobby.

If the SIG does not give any contribution to either political party, then its welfare is obtained by substituting equation the equilibrium policy without lobbying (4.15) into the SIG's objective function (4.14):

$$V_L^0 = \left(r - t^{K^*}\right) K = rK - G$$

Welfare of the SIG if it lobbies a single party (assume without loss of generality that it lobbies party A) is obtained by substituting equations (4.15), (4.16), (4.21) and (4.6) into (4.14):

$$\begin{aligned} V_L^1 &= \left(\frac{1}{2}+b\right)\left[rK - G + \frac{1}{2}\varphi(0)\left(\frac{h}{(1-\alpha)f}\right)^2\right] \\ &\quad + \left(\frac{1}{2}-b\right)(rK-G) - \left[\frac{(1-\alpha)f}{h}\right]^2 L^2\left(W^* - W^A\right)^2 \\ &= rK - G + \left(\frac{1}{2}+b\right)\frac{1}{2}\varphi(0)\left(\frac{h}{(1-\alpha)f}\right)^2 - \left[\frac{(1-\alpha)f}{h}\right]^2\left(t^{LA}L\right)^2 \end{aligned}$$

Welfare of the SIG if it lobbies both parties is similarly obtained as:

$$\begin{aligned} V_L^2 &= rK - G + \frac{1}{2}\left(\frac{h}{(1-\alpha)f}\right)^2\left[\frac{1}{2} - b + 2b\varphi(0)\right] \\ &\quad - \left[\frac{(1-\alpha)f}{h}\right]^2\left[\left(t^{LA}L\right)^2 + \left(t^{LB}L\right)^2\right] \end{aligned}$$

Now, lobbying a single party is preferred to not lobbying at all $\left(V_L^1 > V_L^0\right)$ if (substituting from (4.22)):

$$\begin{aligned} \left(\frac{1}{2}+b\right)\frac{1}{2}\varphi(0)\left(\frac{h}{(1-\alpha)f}\right)^2 &> \left[\frac{(1-\alpha)f}{h}\right]^2\left(t^{LA}L\right)^2 \\ b &> \frac{1}{2}\varphi(0) - \frac{1}{2} \end{aligned}$$

Similarly, we can show that lobbying both parties is preferred to lobbying a single party $(V_L^2 > V_L^1)$ if:

$$\frac{1}{2}\left(\frac{h}{(1-\alpha)f}\right)^2\left[\frac{1}{2}-b+2b\varphi(0)\right]-\left[\frac{(1-\alpha)f}{h}\right]^2\left[\left(t^{LA}L\right)^2+\left(t^{LB}L\right)^2\right] >$$
$$\left(\frac{1}{2}+b\right)\frac{1}{2}\varphi(0)\left(\frac{h}{(1-\alpha)f}\right)^2-\left[\frac{(1-\alpha)f}{h}\right]^2\left(t^{LA}L\right)^2$$

which simplifies to

$$b < \frac{1}{2}\varphi(0)$$

Finally, we can show that lobbying both parties is always preferred to not lobbying at all $(V_L^2 > V_L^0)$ if:

$$\frac{1}{2}\left(\frac{h}{(1-\alpha)f}\right)^2\left[\frac{1}{2}-b+2b\varphi(0)\right] > \left[\frac{(1-\alpha)f}{h}\right]^2\left[\left(t^{LA}L\right)^2+\left(t^{LB}L\right)^2\right]$$
$$-b+(1+2b)\varphi(0)-[\varphi(0)]^2 > 0$$

What do these expressions imply? Suppose that $\varphi(0) = \frac{1}{2}$; that is, the probability of each party winning the election is one-half. Then, the above three conditions simplify to:

$$\begin{aligned} V_L^1 &> V_L^0 \quad \text{if} \quad b > -\frac{1}{4} \\ V_L^2 &> V_L^1 \quad \text{if} \quad b < \frac{1}{4} \\ V_L^2 &> V_L^0 \quad \text{since} \quad \frac{1}{4} > 0 \end{aligned}$$

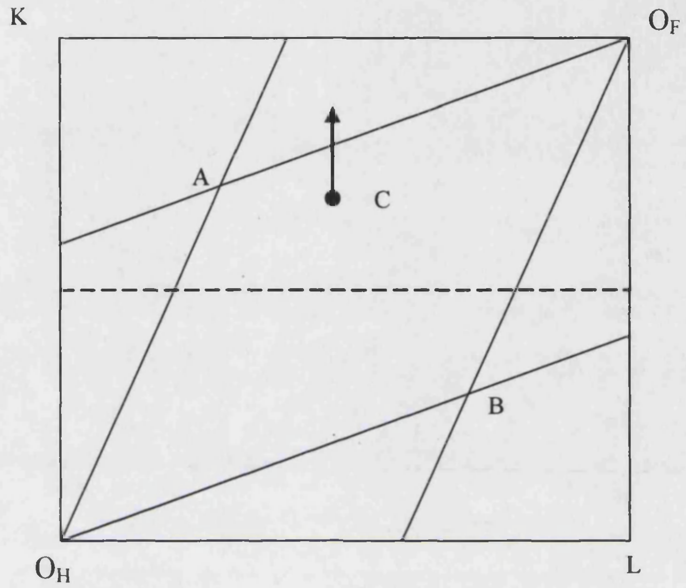
Therefore in this case, lobbying both parties is always superior to not lobbying at all, and is also superior to lobbying only one party if neither party is too popular (b sufficiently small; $b \in \left(-\frac{1}{4}, \frac{1}{4}\right)$).

4.B Capital mobility when the FPE set is not the entire Edgeworth Box

In this Appendix, we discuss the implications for capital mobility, of using a more general functional form for the production functions of the two industries. Suppose that the production functions take the following form:

$$X_1 = x_1(K,L) \qquad X_2 = x_2(K,L)$$
$$\left(\frac{K}{L}\right)_{X_1} > \left(\frac{K}{L}\right)_{X_2}$$

Figure 4.4: The Edgeworth Box and capital mobility when the FPE set is not the entire Edgeworth Box.



That is, production of each good requires both capital and labour, and good 1 is capital-intensive relative to good 2. In this case, the FPE set is a parallelogram which is a subset of the Edgeworth Box (see Helpman and Krugman (1985)). In Figure 4.4, the FPE set is the area $O_H A O_F B$.

Now, in addition to the decision of whether to move between countries, capital in each country also has to decide how much capital will be moved. This poses no additional difficulty to the game; we assume that both decisions of whether and how much to move, are simultaneously decided in the third stage of the game. In equilibrium, it must be the case that, given standard assumptions on the production functions, some capital stock will remain in each country.

Suppose that world endowment is given at point C. Since Home has more capital at point C than does Foreign, Home will implement more pro-capital policies than Foreign. This will encourage capital to flow from Foreign to Home. Once outside the FPE set, however, the relative capital abundance in Home will drive down the rental rate of capital in Home, whilst the relative scarcity of capital in Foreign will drive up the rental rate of capital in Foreign. This higher rental rate in Foreign acts as a force against further flows of capital from Foreign to Home; capital flows will stop once the net return to capital is equalised across countries.

4.C Data Appendix to Chapter 4

The data comes from many sources. Our dataset builds on Ozler, Datt and Ravallion (1996) and Besley and Burgess (2004).

The labor regulation variable comes from state specific text amendments to the Industrial Disputes Act 1947 as reported in Malik (1997). Besley and Burgess (2004) code each change in the following way: a +1 denotes a change that is pro-worker or anti-employer, a 0 denotes a change that was judged not to affect the bargaining power of either workers or employers and a -1 denotes a change which they regard to be anti-worker or pro-employer. There were 113 state specific amendments coded in this manner. Where there was more than one amendment in a year they collapsed this information into a single directional measure. Thus reforms in the regulatory climate are restricted to taking a value of 1, 0, -1 in any given state and year. To use these data, they then construct cumulated variables which map the entire history of each state beginning from 1947 — the date of enactment of the Industrial Disputes Act.

State population data used to express magnitudes in per capita terms and as a control comes from the 1951, 1961, 1971, 1981, 1991 and 2001 censuses (Census of India, Registrar General and Census Commissioner, Government of India) and has been interpolated between census years.

State domestic product comes from Estimates of State Domestic Product published by Department of Statistics, Ministry of Planning, Government of India, and is expressed in log per capita terms.

Fixed capital comes from the Indian Annual Survey of Industries, Central Statistical Office, Department of Statistics, Ministry of Planning, Government of India. It represents the depreciated value of fixed assets owned by the factory on the closing date of the accounting year. Fixed assets are those which have a normal productive life of more than one year. Fixed capital covers all types of assets new or used or own constructed, deployed for production, transportation, living or recreational activities, hospitals, schools etc. for factory personnel.

Variables expressed in real terms are deflated using the Consumer Price Index for Industrial Workers, obtained from several publications including the Indian Labour Handbook, the Indian Labour Journal, the Indian Labour Gazette, the Reserve Bank of India Report on Currency and Finance, and the Monthly Abstract of Statistics of India.

Total installed electrical capacity of electrical generation plants is measured in thousand kilowatts and come from various issues of the Statistical Abstracts of India, Central Statistical Office, Department of Statistics, Ministry of Planning, Government of India. It is expressed in logs.

The data on political histories comes from Butler, Lahiri and Roy (1991), updated from the website of the Election Commission of India (http://www.eci.gov.in/). Political history is measured by the number if years during our data period that particular political groupings have held a majority of the seats in the legislature. State political configurations are held constant between elections. In our data period, the relevant groupings are: the Congress party, the Janata parties, hard left parties, the Hindu parties, and regional parties. These groupings contain the following parties (i) Congress Party (Indian National Congress + Indian Congress Socialist + Indian National Congress Urs + Indian National Congress Organization), (ii) Janata parties (Lok Dal+Janata+Janata Dal), (iii) a hard left grouping (Communist Party of India + Communist Party of India Marxist), (iv) Hindu parties (Bharatiya Janata Party (BJP)), and (v) a grouping made up of regional parties.

Banking data refers to scheduled commercial banks: State Bank of India and its associates, Nationalized banks, Regional rural banks, Private sector banks, and Foreign banks. Data on bank credit is from the Reserve Bank of India publication Statistical Tables Relating to Banks in India.

Industry data is from the Indian Annual Survey of Industries. Data is available at the 3-digit level, following the National Industrial Classification (NIC). There is a change in industrial classification in 1987 and, in order to match the 1970 and 1987 NICs, we aggregate a small number of 3-digit industries. We exclude miscellaneous manufacturing industries, as these are likely to be heterogeneous across states. The industries 'Minting of Currency Coins' and 'Processing of Nuclear Fuels' are also excluded, as outcomes in these industries are likely to be determined by special considerations. This leaves a total of 138 industries.

Chapter 5
Conclusion

When an engineer is asked to design a car, his first question is: what type of car am I being asked to design? Is it a sports car, or a luxury car, or a family car, or a car for the urban commuter? Each type of car has its own special characteristics, whilst retaining several common characteristics such as four wheels, a steering wheel, an accelerator and brake pedals. Likewise, economists, when attempting to address some economic question, ask first what type of model is required. This has resulted in the proliferation of economic models. Each type of model has its own special characteristics, while retaining certain elements in common with other economic models. Each model explains well certain features of the world, and may be used as a basic framework of analysis in other applications, but without any pretence to unversal generality (just as no car engineer would claim that his car is suitable for all purposes). It is precisely this implementation of different models to address different issues that is at the heart of this dissertation. This concluding chapter will first highlight once again the key findings of the previous chapters, then widen the discussion to address possible extensions to the work presented here.

The motivation for this dissertation has been to shed some light on two closely related questions: How is economic activity distributed across space, and how can we explain this distribution? A series of three chapters focussed on three different aspects of these questions: the size distribution of cities, the relationship between factor endowments and industrial structure, and the role of absolute factor endowments and politics in determining the structure of production. In each chapter, these aspects are analysed at different levels of analysis, namely empirical description, empirical explanation, and theoretical explanation.

In chapter 2, I reconsider the empirical evidence regarding Zipf's Law: the idea that city sizes follow a Pareto distribution with shape parameter equal to 1. Using a new dataset, the oft-claimed universality of Zipf's Law is rejected. Zipf's Law is rejected for 53 out of 73 countries using OLS, and for 30 out of 73 countries using the alternative Hill estimator.

Chapter 3 considers the role of factor endowments and technology in determining the pattern of industrial activity in India. Using a panel dataset across 16 states, 18 industries and 18 years, these factors are found to play important roles. This finding is robust to the inclusion of additional controls for political history and government policies. There is also evidence of structural breaks in the relationship between factor endowments, technology, and industrial structure corresponding to the liberalisation of the Indian economy beginning in 1985 and 1991; however, the impact of these reforms varies across industries.

In chapter 4, I investigate how initial conditions in terms of absolute factor endowments can impact on economic policy and the structure of production. A theoretical model based on political economy is developed whose main prediction is that the more capital there is in a given jurisdiction, the more favourable towards capital will be policies, because of lobbying activity by the capital owners. This then has implications for incentives for capital mobility and hence the structure of production. These outcomes of the model are found to be consistent with evidence from India using a panel of 16 states over 39 years.

There are a number of interesting directions for future research. First, for city size distributions, now that there is a newer and more comprehensive description of what the actual size distribution of cities looks like, new theoretical models that capture more of these features may be developed. One possible difficulty with this line of research is that the pervasive presence of power laws in the natural world (e.g. rivers, earthquakes, volcanic activity, solar flares, forest fires, the extinction rate of biological species) appears to suggest that this is really some "natural" outcome that may be difficult to model with models based on the tradeoffs faced by maximising agents. On the empirical side, recent work by Black and Henderson (2003), Dobkins and Ioannides (2000, 2001), Ioannides and Overman (2003, 2004), Overman and Ioannides (2001) for example shows what is perhaps the most promising direction of research: focussing on the evolution over time and space of a system of cities.

Next, for the relationship between factor endowments, technology, and industrial structure, at least two empirical extensions can be considered. The first is mainly descriptive: if we go into greater detail, down to the 3- or 4-digit levels, what is the distribution of these industries across states and over time? Second, the impact of the 1991 liberalisation in India can be examined in greater detail. Recent work by Aghion, Burgess, Redding and Zilibotti (2004) suggests that industries close to the world technology frontier benefited more from the liberalisation than industries further from the frontier. A related question would be to explore the determinants of economic growth in India, the contributions of factor accumulation, TFP growth, and liberalisation to this growth. It may also be possible to estimate more formally the impact of economic geography models following the framework used in Redding and Venables (2004).

Finally, the relationship between politics, policy, and industrial structure offers great scope for extensions. One implication of the theoretical model in Chapter 4 was that how favourable to capital is policy depends on the parameters of the model, including the effectiveness of lobbying activity. Given data on government policies and the dissemination of communications technologies over time and across countries, it should be possible to estimate the impact of these additional implications of the theoretical model. We can also ask the question of whether improved communications technology strengthens the influence of special interest groups, by making political campaigning more effective, or weakens their influence, by providing voters with more information on the true policies of the political parties (see for example the discussion on the relationship between the media and politics in Besley, Burgess and Prat (2002)).

From a theoretical viewpoint, the political economy model in Chapter 4 may also be used as the basis of a model to shed light on the asymmetric liberalisation of capital and worker flows with the enlargement of the EU. While the long run goal of the EU is to achieve free mobility of both capital and people across member countries, in the short run more restrictions have been imposed on the movement of workers than capital across borders. It may be the case that capital lobbies have played a role in making capital flows easier, to enable them to benefit from low-cost labour in new member countries, while restricting labour flows for an initial period of up to seven years. We could also consider a dynamic setting where we consider capital accumulation rather than capital movement across locations. Although the basic outcome of the model would not be changed, a dynamic framework might yield additional insights.

In the introduction I asked the question of what determines the spatial distribution of economic activity. This research project has investigated these determinants by studying the size distribution of cities, industrial location in India, and the interplay between politics and economic activity. The main finding has been that, in all of these cases, the location of economic activity is determined by a combination of factor endowments, market access, and politics and government policy. Only by investigating the joint influence of these considerations can we understand the distribution of economic activity across space.

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