Essays on Archaic Institutions and Modern Technology

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Declaration

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London, November 30, 2012

Ashwini Natraj

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Abstract

I present three essays discussing the impact of archaic institutions and technology on inequality in wages and political participation. First I examine a modern facet of the Indian caste system: political quotas for disadvantaged minorities and their impact on political participation. I find that aggregate turnout falls by 9% of the baseline and right-wing parties win 50% more often, but electoral competition is not significantly affected. Detailed individual-level data for one state suggests that voter participation falls among women and minorities. This suggests that restricting candidate identity to minorities may cause some bias in voter participation.

Next, I study caste and human capital: specifically why workers remain in low-paying hereditary occupations, providing an explanation for both occupational specialization and hereditary occupations. I use a simple model of insurance provision in which parents pass on human capital to their children in return for insurance in the event of sickness, and find that workers with low human capital are likelier to participate in the arrangement, and that a higher cost of sickness can sustain higher human capital transfers.

I conclude by studying human capital and technology- the impact of information and communication technologies (ICT) on wage inequality. We tested the hypothesis that information and communication technologies (ICT) polarize labour markets, by increasing demand for the highly educated at the expense of the middle educated, with little effect on low-educated workers. Using data on the US, Japan, and nine European countries from 1980-2004, we find that industries with faster ICT growth shifted demand from middle educated workers to highly educated workers,

consistent with ICT-based polarization. Trade openness is also associated with polarization, but this is not robust to controlling for Research and Development. Technologies account for up to a quarter of the growth in demand for highly educated workers.

Introduction

I Overview

The following essays consider one of the several paradoxical facets of developing countries: the tension between ancient institutions and the forces of modernity, whether they arrive in the form of competition, technology or both. This is particularly striking in India, a country in which rapid technological advancement coexists sometimes uneasily with the stubborn persistence of archaic institutions. One such institution is that of the caste system, which has exhibited considerable resilience in the face of economic growth and urbanisation, and shows every sign of using information and communication technology to further entrench itself (as evinced by the persistence of endogamy in modern India (Banerjee, Duflo, Ghatak, and Lafortune (2009))).

The first two essays consider two aspects of the caste system. Chapter 1 deals with an attempt to correct the disenfranchisement of citizens at the bottom of the caste hierarchy, and Chapter 2 considers the benefits of occupational specialisation and intergenerational occupational rigidity. The final two chapters consider the accumulation of human capital first in an environment with imperfect capital markets and no obsolescence, and second through the lens of Information and Communication Technologies and their impact on skill demand.

II Chapter Summaries

II.1 Chapter 1

A representative democracy should seek to reflect the needs of its entire population, but there is a concern that a nation's elected representatives do not serve the needs of its most vulnerable citizens. Many countries, concerned that these citizens are not adequately represented in their governments, have sought to redress the balance with quotas. Advocates of the policy suggest that the identity of a legislator affect her policy preferences, so at the least imposing quotas may have redistributive effects (Pande (2003), Chattopadhyay and Duflo (2004)).

One key assumption made when assessing the impact of quotas on policy preferences is that quotas change only legislator identity, leaving voter identity unaffected. Moreover, critics of quotas claim that quotas are by their nature uncompetitive, since by changing the candidate pool they distort incentives and weaken electoral competition.

In Chapter 1, I use a provision of the Constitution of India to examine the causal impact of the introduction of quotas for disadvantaged minorities on electoral competition and voter participation, at the level of the constituency, and find that while quotas have no discernible adverse effect on electoral competition, they depress turnout. Detailed data for a subsample suggest that quotas depress turnout especially among women and minorities.

II.2 Chapter 2

While Chapter 1 dealt with a present-day outcome of the caste system, I now turn attention to one reason for its persistence- intergenerational occupational rigidity as a means of procuring insurance in the presence of imperfect credit markets.

Occupational rigidity is a much-studied phenomenon. Explanations vary from the cost of acquiring human capital in the presence of indivisible human capital investments and capital market imperfections (Bannerjee and Newman (1993)) to the information advantages of family, village, ethnic or occupationally specialized networks (Akerlof (1976), Greif (1993), Freitas (2006)). One persuasive explanation is that social networks provide access to consumption-smoothing (Munshi and Rosenzweig (2009)).

I use a two-period Overlapping Generations model in which a parent with an endowment of occupation-specific human capital transfers costly human capital to her offspring, in return for full insurance if the parent suffers an accident, with the penalty for default being a bar from access to to the insurance arrangement. I find that agents with low human capital are more liable to participate in the insurance arrangement, and that the maximum sustainable human capital transfer rises with the cost of sickness.

II.3 Chapter 3

Chapters 2 and 3 deal with two conflicting forces on human capital- in Chapter 2 agents accumulated human capital in order to have a means of insurance against sickness, in an environment with no obsolescence owing to technology, whereas in Chapter 3 I consider the impact of Information and Communication Technology on the demand for workers across varying occupation and education groups.

The demand for highly-skilled workers in the UK, USA and a range of developed countries has risen significantly in the past three decades, outstripping even the rise in supply of workers with a college education over the same period. Most authorities agree that this increase is brought about by technological changes rather than a shift in trade with low-wage countries.

A persuasive hypothesis is that technical change complements highly-skilled workers at the benefit of all others, but a more granular view of the wage distribution suggests that other factors may be in play. An increase in demand for highly-skilled workers is reflected in higher wages, but interestingly, in the USA, the ratio of the wages of workers in the 90th percentile to those in the 50th percentile have risen far faster than those in the 50th percentile to those in the 10th percentile and lower.

An explanation uniting both these observations is provided by the "polarization hypothesis"(famously propounded by Autor, Levy, and Murnane (2003)), which suggests that an increase in the use of Information and Communication Technology complements those performing non-routine tasks but substitutes those performing routine tasks.

Many non-routine cognitive tasks (e.g. surgery or consulting) are performed by highly educated workers, while many routine cognitive tasks (e.g. clerical) were performed by middle-skilled workers, who were gradually replaced by ongoing computerization. Low-skilled workers frequently perform non-routine manual tasks (e.g. grading and sorting of agricultural products). Routine manual tasks performed by low-skilled workers (e.g. assembly-line manufacturing) dropped out of the pictures after the 1970s, and so the greatest gains were experienced by the highly-skilled group, and the greatest loss by the *middle* group.

Using data from the United States Census and the Directory of Occupational Titles, we show first that middle-skilled workers cluster disproportionately in routine cognitive tasks, and low-skilled workers have a high presence in non-routine manual tasks. Then, using the EUKLEMS dataset providing capital accounts and labour disaggregated by education group for a panel of 11 OECD countries (the US, Japan and 9 other OECD countries) over 25 years (1980-2004), show that those industries with the fastest increase in ICT compensation did indeed show the greatest increase in demand for college-educated workers and the greatest fall in demand for middle-skilled workers, consistent with the polarization hypothesis.

III Contributions to the Literature

III.1 Chapter 1

In Chapter 1, I consider the impact of legislative quotas on the *voting* population, which has so far been neglected in favour of studying the impact of these measures on *candidates*. I provide an understanding of the impact of quotas on electoral competition, how many vote and *who* votes as a result of quotas. Chapter 1 also contains an analysis of political reservation at the constituency level, which is not only a meaningful unit of consideration for political variables, but examines permanent quotas at a more disaggregated level than the state.

III.2 Chapter 2

Chapter 2 provides a simple model of human capital accumulation as a means of consumption-smoothing, and its theoretical contribution is to unite the views of castes or guilds as a means of safeguarding human capital or intellectual property with the more recent literature treating social networks as a means of contract enforcement, eradicating information asymmetries or providing insurance.

III.3 Chapter 3

This paper is the first to provide direct international evidence that skills-technology complementarity benefits highly-skilled workers at the cost of middle-skilled workers, consistent with the polarization hypothesis. Other work has shown a similar substitution Autor, Levy, and Murnane (2003), Autor and Dorn (2009) but only for America. Prior to this, Autor, Katz, and Krueger (1998) show that the rise in the use of computers between 1984 and 1993 was correlated to a fall overall in the demand for high-school graduates between 1979 and 1993, but we provide evidence for a panel of 11 countries over a longer time-period.

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Chapter 1

Some Unintended Consequences of Political Quotas

1.1 Introduction

Many countries have considered measures to increase the representation of minorities and women, either through quotas or through gerrymandering[1]. In India, quotas have been in place for disadvantaged groups since 1951, but the policy's use is widespread. In 2010, more than 30 countries in Asia, Africa, South America and Europe had quotas for women in government.

Proponents of the policy point out that there is reason to believe that nonminority legislators have different policy preferences from legislators from disadvantaged groups. So, in addition to considerations of fairness and equity, empirical evidence suggests that increasing representation for disadvantaged groups may have redistributive effects (Pande (2003), Chattopadhyay and Duflo (2004)).

However, a common assumption made when assessing the impact of legislator identity on policy is that the imposition of political quotas changes legislator identity only, while voter identity is unaffected (Pande (2003)). This is a strong assump-

[1]Section 5 of the Voting Rights Act of America contains provisions that many conservative politicians see as racial gerrymandering. See also Shaw v. Reno, 113 S.Ct.2816(1993), in which the Supreme Court ruled that the creation of a district in North Carolina in which minorities were in the majority was unconstitutional.

tion, and not innocuous. Critics of quotas, moreover, argue that they are discriminatory, distort incentives and by their nature undermine the democratic process: intervention in order to increase minority representation takes away the right of voters to choose their representatives freely. Artificially restricting the pool of candidates weakens electoral competition.

This paper uses a provision of the Constitution of India to examine the causal impact of the introduction of quotas for disadvantaged minorities on electoral competition and voter participation, at the level of the constituency.

The world's most comprehensive political affirmative action programme takes place in India, in which approximately a quarter of all state and national legislators belong to disadvantaged groups. The representation of members belonging to historically disadvantaged castes (Scheduled Castes or SCs) or tribes (Scheduled Tribes or STs) is determined according to each decennial census, and the representation of these groups in the state legislature is held to be as close as possible to their representation in the population. Reservation is revisited with the publication of each decennial census, but not before. When a constituency is reserved for SCs(STs) only SC(ST) candidates may contest the election, although voters of all identities may vote.

In 2008, after a long hiatus since 1981, a wave of redistricting (Delimitation) was carried out, adjusting the representation of SCs and STs in state and national legislatures according to the 2001 census. Four states (Karnataka, Madhya Pradesh, Rajasthan and Chattisgarh) carried out elections using this adjusted representation. The documentation released laid out the methodology of reservation transparently, enabling me to construct for these states a unique dataset with those constituencies which were reserved for the first time in 2008, as well as demographically and economically comparable constituencies within the same administrative area which narrowly missed the reservation cutoff and remained unreserved. I use a Differences-in-Differences approach to examine the impact of political reservation on turnout, the number of candidates contesting, the margin of victory and the probability of success of right-wing and left-wing parties, as well as those mobilising lower-caste supporters (details in Section 1.2.4).

I find no impact on the number of candidates contesting and no impact on the margin of victory, so these conventional measures of electoral competition are unaffected by political quotas. However, turnout drops by 6 percentage points relative to a baseline of 69 percentage points, and right-wing parties make up 26% more of winners in reserved constituencies after reservation, compared to a baseline of 53%. Results using individual polling data suggest that women vote 15% less, and minorities vote 9% less, in reserved constituencies after reservation.

There are many possible explanations, but at the very least this evidence suggests that there are unintended consequences to political quotas- although most standard measures of electoral competition are unaffected, voter participation falls, and seemingly among the most vulnerable members of the population.

This is a concern, because for a complete picture of the impact of minority representation on policy it seems reasonable to look at its impact on the size and composition of the voting population. We should be concerned if sections of the population systematically choose to increase participation- or to reduce it. When suffrage is extended to a group, public goods provision to the group improves as well. An increase in the participation of underprivileged voters causes a rise in welfare expenditure (Husted and Kenny (1997)) and public health and infrastructure spending (Lizzeri and Persico (2004)); better public goods provision (Naidu (2009)); better health outcomes (Fujiwara (2010)) and better resource targeting (Besley, Pande, and Rao (2005)).

This work belongs to several streams of work in the economic and political science literature. There is of course a large body of work examining the impact of legislator identity on policy, using the Indian experiment I discuss. In addition, the work addresses literature discussing the impact on political competition of gerrymandering, as well as the literature on political participation and ethnic conflict.

There is a large literature on ethnic conflict in developing nations, starting from

Donald Horowitz's seminal work (Horowitz (1985)) and related to the Indian context by Kanchan Chandra (Chandra (2003)) and the African context in Collier and Vicente (2011), Collier and Vicente (2012). There is a recent literature on ethnic conflict and clientelism in democracies in Africa, considering the electoral success of vote-buying and means of combatting it. Wantchekon (2003) finds that vote-buying distorts redistribution, but proves electorally successful. Vicente and Wantchekon (2009) find that increasing voter information and the political participation of women is associated with a reduction in clientelism.

There is also a growing body of work examining the tradeoff between preferences regarding politician type and group identity: studies finding that increasing voter ethnicisation in North India adversely affects candidate quality in dominant groups (Banerjee and Pande (2007)) ; in contrast, finding that reservation, by creating a dominant group, tends to increase the competence of elected representatives, and resolve the inability of candidates to credibly commit to a platform (Munshi and Rosenzweig (2008)). Atchade and Wantchekon (2007) find that electoral support for broad-based reform is greater when voters share ethnic ties with candidates.

There is little work examining the impact of quotas on the size and composition of the voting population. The political science literature, while considering increased minority representation as a determinant of turnout, focusses on partisan gerrymandering. Discussing the merits of racial gerrymandering, Cameron, Epstein, and O'Halloran (1996), examining majority-minority districts in America, suggest that there may be a tradeoff between "descriptive" representation- i.e. increasing the number of minority officeholders- and "substantive" representation- policies benefitting minorities. See Besley and Case (2003) for a survey; Coate and Knight (2007) for a model of optimal redistricting.

There is no consensus on the impact of majority-minority districts on voter participation: early work suggests that African-American participation might increase, but absent substantive representation, might peter out (See Barreto, Segura, and Woods (2004) for a review of the literature, as well as the argument that other minorities may participate more as a result of redistricting).

The existing work on political quotas tends to mainly examine quotas using the lens of the impact of legislator identity on policy (see Duflo (2005) for a review) with some recent work examining the impact of political reservation on poverty (Chin and Prakash (2009)), and the impact of political reservation for women on reports of crimes against women (Iyer, Mani, Mishra, and Topalova (2011)).

Previous work on political reservation in India has examined either the state level (Pande (2003)) or village council level (Chattopadhyay and Duflo (2004)). Measures at both levels are not quite comparable, however. At the village council level, quotas rotate on a predictable basis, so performance incentives are fundamentally different from quotas at state and national level, which are expected to be permanent. I examine permanent quotas at the level of the constituency, which enables me to look at the impact of restricting candidate identity for a material election at a quite disaggregated level.

Ford and Pande (2011), in a survey of the literature on gender quotas, state that there is limited evidence on the impact of quotas on turnout. Kurosaki and Mori (May 2011) examine the correlation between the probability of minority citizens voting and the incidence of being in a constituency reserved for minorities, but they do not exploit time variation and they cannot directly identify the causal impact of reservation on voting outcomes.

This work makes the following broad contributions: an understanding of the impact of quotas on the voting population and electoral competition, and an analysis of political reservation at the constituency level, which examines permanent quotas at a more disaggregated level than the state and is a meaningful unit of consideration for political variables.

The rest of this paper is organised as follows: Section 1.2 provides a conceptual framework. Section 1.3 provides a background of political reservation in India. Section 1.4 sets out my identification strategy in more detail, and Section 1.5 sets out the empirical specification. Section 1.6 provides some data and summary statistics and Section 1.7 results for aggregate turnout and competition. Section 1.8 describes individual-level data for one state in the sample, along with results. Section 1.9 concludes, with some ideas for further work.

1.2 Theoretical Predictions about Turnout, Electoral Competition and Party Bias

In this section, I discuss the extant theory regarding the impact of restricting legislator identity on turnout and electoral competition, and its main predictions.

There are no clear theoretical predictions regarding the impact of political quotas on turnout, competitiveness or party bias, since the phenomenon has not been explicitly modelled. We can, however, disentangle some of the effects of the imposition of political quotas on turnout, electoral competition and party bias.

Political quotas (or "reservation"in the Indian example) imply restricting the pool of eligible candidates in a single-member jurisdiction to a subset of the population. This has a host of possible effects on the number and type of legislators contesting [2], but here I enumerate what certainly happens: all candidates now belong to the same broad ethnic group; a subset of minorities is guaranteed representation and all candidates are now more alike on at least one dimension.

What theory there is offers very different predictions, depending on initial conditions.

1.2.1 Ratio of Candidates to Electors

The impact of reservation on the number of candidates depends crucially on whether reservation induces new minority candidates to contest (generating a new pool) or whether those candidates who would contest elections after reservation did so prior to the policy anyway. In the first case, the impact of the policy would be

[2] One obvious one being that minority candidates may well be less educated, on average, than nonminority ones

ambiguous. In the second, trivially the ratio of candidates to electors is lower in reserved constituencies after reservation than in nonreserved constituencies.

1.2.2 Margin of Victory

The impact of reservation on the margin of victory goes in the same direction as variation within the pool of minority candidates. If the two minority candidates are closer (in quality, for example) than are a minority and nonminority candidate, then the margin of victory should reduce. If not, then it should widen.

1.2.3 Turnout

Voting behaviour has long been a vexed question in the theoretical and empirical literature, exemplified by the "paradox of voting": i.e. with costly voting and large populations (and therefore a small probability of being pivotal) nobody ought to vote (Downs (1957); Ordeshook and Riker (1968)); see Feddersen (2004) for a survey.

Reservation could affect turnout through a large number of mechanisms, which would pull in different directions. Here I enumerate some of these mechanisms, and predictions consistent with these mechanisms.

1.2.3.1 Competition

There is a long tradition in the political science literature that turnout is higher in elections expected to be close. (from Palfrey and Rosenthal (1983), in close elections, the probability of being pivotal increases; from Ferejohn and Fiorina (1975) voters seek to minimise their regret in the event of their preferred candidate losing by a narrow margin; see Geys (2006) for a review). If reservation affects turnout through competition, turnout should go *in the same direction as electoral competition*, irrespective of the ethnic group of voters.

1.2.3.2 Expressive Voting

The idea of a benefit from voting is an old one in the political science literature, whether it be a desire to do one's democratic duty (Downs (1957)) or to assert one's partisanship (Ordeshook and Riker (1968)). In this setting, voters derive benefit from voting for candidates sharing their group identity. After reservation, a subset of minorities is guaranteed representation. Nonminority voters and minority voters who are not represented are effectively disenfranchised and lose their incentive to vote, and minority voters guaranteed representation have no added incentive to vote, since a candidate from their broad ethnic group is guaranteed to win. If this mechanism were in operation, turnout on average would *fall for all groups*, particularly for elites and non-represented minorities.

1.2.3.3 Identity as Information

While "expressive voting"explores rational participation, others consider rational abstention. For instance, Feddersen and Pesendorfer (1996) posit that in elections in which candidates have distinct positions and voters are asymmetrically informed and vary in partisanship, it may be rational for uninformed nonpartisan voters to abstain[3]. Aker, Collier, and Vicente (2011) find that targeted information campaigns increase the participation of voters in Mozambique [4]. In the setting I consider, it is possible that voters use a candidate's group identity as a proxy for information about her quality, policy preferences or both. Once all candidates belong to the same ethnic group, a salient source of information is lost. Were this to operate, reservation should *depress turnout among uninformed voters*.

[3]Making voting more salient can also increase turnout, dating from the study of Gosnell (1927), who found for presidential elections in 1921 and municipal elections in 1925

[4]See also Pande (2011) for a review of the literature on voter information, electoral accountability and governance

1.2.4 Party Bias

In the current setting, I consider parties based on two broad criteria, redistribution (i.e. whether a party have a history of opposing policies (e.g. directed taxation) that redistribute income from the wealthy to the poor) and reservation (i.e. whether a party has a history of opposing measures that redistribute resources towards disadvantaged minorities). Parties that answer "Yes"to both questions are classed as "Right-Wing"[5]. Parties that answer "No"to both questions (or who have a history of favouring redistribution along either dimension) are classed as "Left-Wing"[6]. A third category is "Lower-Caste parties", who direct their appeal specifically towards voters from the bottom of Hinduism's caste hierarchy [7]. What does reservation imply for the success of these groups of parties? Effects operate along two dimensions, the effect on candidates, and that on voters.

1.2.4.1 Candidates

Does reservation induce changes in the distribution of right-wing, left-wing and lower-caste parties among contesting parties? If so, then in constituencies where right-wing/left-wing/lower-caste parties win disproportionately, we should expect to see these parties make a higher fraction of contesting candidates. If we find no significant difference in the distribution of all contesting parties between treated and untreated constituencies, any difference we find is due to the efficiency of these parties in mobilising support from voters (see the "mobilisation"models of Nalebuff and Schachar (1999), for instance, in which group leaders exert social pressure to mobilise their followers).

[5]In practice, this is most usually the "Bharatiya Janata Party"(or "Indian People's Party"), a party which is socially conservative, in favour of free markets and of whose base upper-caste Hindus make a large fraction.

[6]This group is large, including the Indian National Congress (India's oldest political party) and Communist Party of India, and offshoots thereof.

[7]In practice, this is the "Bahujan Samaj Party"(or "Oppressed People's Party").

1.2.4.2 Voters

Does reservation induce changes in the composition of the voting population in order to disproportionately favour a group of political parties? If so, then in constituencies where right-wing/left-wing/lower-caste parties win disproportionately, we should expect to see voters identifying themselves as supporters of right-wing, left-wing and lower-caste parties (respectively) should make a higher fraction of the voting population.

Note further that while the above discussion makes no definitive predictions regarding the distribution of political parties as a result of reservation, it offers some suggestive leads as to the composition of the voting population- in particular, it suggests that uninformed voters may abstain. If a lack of information is also correlated with a lack of education or wealth, then when uninformed voters drop out local elites make a higher fraction of the voting population, which means that if "informed" voters disproportionately favour a political party, reservation will bias victory in favour of that party.

1.3 Reservation in India

After 1950, the Indian Government enforced mandated representation for traditionally under-represented minorities, the Scheduled Castes (SCs) (who belong to castes at the bottom of Hinduism's caste hierarchy) and Scheduled Tribes (STs) (members of which belong to tribes living in remote areas, historically cut off from technology, education and healthcare). As near as possible, the representation from each state in State and National Legislative Assemblies would be equal to the proportion of their population in the state, according to the last decennial census. While the representation of these communities in the population varies continuously, their representation in the legislature varies with a lag in intercensal years. The fraction of reservation has remained fixed since the 1981 census. In 2008 the Delimitation Commission of India conducted a revision according to the 2001 census for elections in or after 2008.

When a seat is reserved for a member of the Scheduled Castes (Tribes), only Scheduled Caste (Tribe) candidates may contest, though all voters on the electoral roll may vote. From 1962, all constituencies are single-member jurisdictions. Elections are conducted on a First-Past-the-Post (FPTP) system: the candidate with the highest number of votes wins and represents the constituency in the state legislative assembly.

One difference between reservation in the state and national assemblies and that at the Panchayat (village council) level is that in the former case reserved seats do not rotate- a seat, once reserved, will remain so as long as it meets the criteria of the Election Commission.

1.4 Identification Strategy

Quota allocations are determined at three levels: State, District and Constituency. The hierarchy is as follows: directly beneath the state is a district, which comprises many constituencies. A district is allocated SC seats in a proportion roughly equal to how many of the state's SCs live in that district. Constituencies in a district are ranked in descending order of proportion of SCs until the district quota is satisfied.

Figure A.1 illustrates the process of allocation of reserved constituencies to a district. If State X has 15 SC seats and 20% of the state's SCs live in district A, district A gets 3 SC seats. Constituencies are ranked in descending order of SC population until the quota is reached.

Since seats are reserved for minorities based on their representation in the constituency, the identification of reservation on turnout or electoral competition is not straightforward. However, the procedure described suggests a Differences-in-Differences approach [8]:

[8] The control group is identified using an approach akin to that of Clots-Figueras (2007) who, examining the impact of female legislators on education expenditure, instruments female presence in administration with females who won elections against men by a narrow majority; Fujiwara (2010) compares the impact of the introduction of Electronic Voting Machines between cities of population

1.4.1 Construction of Treatment and Control Groups (SC constituencies)

For each district, I identify the lowest SC proportion for an SC-reserved constituency. This becomes the cutoff for reserved constituencies in each district.

Figure A.2 illustrates the district cutoff in our example. 3 seats were reserved for SCs in district A, and the lowest SC population among reserved seats was 30%.

I then narrow consideration to constituencies with an SC population within 3 percentage points of the district cutoff: in our example, as illustrated by Figure A.3, constituencies with an SC population at least equal to 27% and no more than 33%.

I discard constituencies that were previously reserved, since I am interested in the effects of being reserved for the first time in 2008 (see figureA.4). This leaves me with the following subgroups: (i) the treatment group, constituencies which were switched for the first time from nonreserved to SC in 2008 *and* with an SC proportion no more than 3 per cent higher than the district cutoff; and (ii) the control group, constituencies which were never reserved *and* with an SC proportion no more than 3 per cent lower than the district cutoff.

As in Figure A.5, the treatment group would be: first- time - reserved SC constituencies with an SC population no more than 33 per cent. The control group would be never - reserved constituencies with an SC population no lower than 27 per cent.

1.4.2 Construction of Treatment and Control Groups (ST constituencies)

The process of allocating quotas to STs is different, since this community is more geographically concentrated. The state quota for STs is determined similarly to that for SCs, but constituencies are ranked in descending order of ST population until the state quota is reached. For this reason, using a similar identification strategy leaves

at least as high as 100000 and cities just below that population threshold.

very few observations, so from now on I confine my discussion to reservation for SCs.

1.5 Empirical Specification

I wish to measure the impact of restricting candidate identity on turnout, the ratio of candidates to electors, the margin of victory and the probability of success of right-wing parties. I use a Differences-in-Differences approach, and regress dependent variable Y (turnout, the ratio of candidates to electors, the difference in voteshare between the winner and runner-up or the probability of success of various party groups) on the incidence of being in a constituency reserved for the first time in 2008 ($TREAT$), the incidence of being in a year after reservation ($POST$) and that of being in a reserved constituency after reservation ($TREAT \cdot POST$), in constituency c in year t.

$$Y_{ct} = \beta_0 + \beta_1 TREAT_c + \beta_2 POST_t + \beta_3 TREAT_c \cdot POST_t + u_{ct} \quad (1.1)$$

β_3 identifies the effect of reservation on turnout, electoral competition and party bias under the identifying assumption of common trends between treatment and control groups. In the following section, I test for systematic initial differences between the treatment and control groups.

1.6 Data

Four states in India carried out elections using the new rules in 2008: Chhatisgarh, Madhya Pradesh, Karnataka and Rajasthan. Applying the rule described above leaves me with 107 constituencies for SC constituencies. The four states in the sample carried out elections in 2003 and 2004. Delimitation in line with the 2001 Census was announced in 2006, so I discount bias owing to prior anticipation of treatment at least within the sample. The Delimitation Commission of India released detailed documents along with the 2008 announcement, from which I can reconstruct the reservation of each constituency. This process is not as transparent for previous rounds of reservation, so I restrict myself to one election year before and after reservation. Further details on construction of the treatment and control group are provided in Section C.

1.6.1 Summary Statistics: Village Averages

Table B.1 presents baseline village averages for treated and untreated constituencies, from the 2001 Census of India. There are, on average, 10 villages in each constituency. As Table B.1 makes clear, constituencies in the treatment and control groups do not differ significantly across a battery of characteristics including population, literacy, employment or fraction of young. Treated constituencies had an SC population of 21% in 2001 as opposed to 19 % in untreated constituencies. Illiteracy in to-be-reserved constituencies was 53% in 2001 in both treated and never-reserved constituencies. Unemployment was 47% in to-be-reserved constituencies and 48% in never-reserved constituencies.

1.6.2 Summary Statistics: Constituency Averages

Panel A of Table B.2 presents baseline constituency-level electoral characteristics for treated and untreated constituencies. To-be-reserved constituencies had fewer candidates from right-wing or centre and centre-left parties among all candidates contesting the election, but did not differ significantly in the victory rates of left-wing or right-wing parties[9]. There are also no significant differences in gender representation: 5% of all candidates (and 3% of all winners) in to-be-reserved constituencies in 2003 and 2004 were female, versus 6% of all candidates (and 3% of

[9]In addition to the Communist Party of India and splinter groups, I class India's oldest political party (The Indian National Congress) and its offshoots as Left/Centre-Left."Lower-Caste"parties are those whose manifestoes or rhetoric are directed towards those at the bottom of the caste hierarchy. In practice, this is effectively one party: the Bahujan Samaj Party, or the Party of the Oppressed Majority.

winners) in untreated constituencies[10].

Panel B of Table B.2 presents constituency-level electoral characteristics after treatment for treated and untreated characteristics. In 2008, to-be-reserved constituencies had fewer candidates from right-wing or left/centre-left parties, but 23% more winning candidates came from right-wing parties in treated constituencies, and (unsurprisingly enough) 20% fewer of the winning candidates came from left-wing parties.

Table B.3 presents constituency-level averages of the dependent variables for to-be-reserved and never-reserved constituencies. There are no significant differences between the treatment and control groups prior to reservation over any of the dependent variables. Turnout in 2008 was seven percentage points lower in reserved constituencies compared to never-reserved constituencies. Right-wing candidates made 63% of winners in constituencies reserved in 2008, versus 41% in never-reserved constituencies. The bottom panel presents differences in differences for the four dependent variables. The change in turnout was six percentage points lower in reserved constituencies. The share of right-wing winners rose by 11% in reserved constituencies, and fell by 16% in never-reserved constituencies.

We might be concerned that the differences-in-differences that we observe with the victory of right-wing candidates are driven entirely by changes coming from the control group, rather than the treatment group. However, right-wing candidates made up 2% fewer of winning candidates in all SC constituencies moving from 2003 or 2004 to 2008; 26% fewer of all winning candidates in ST constituencies, and 5% fewer of all winning candidates in all nonreserved constituencies. Right-wing parties, therefore, were less successful in 2008 than in 2003 or 2004 everywhere but in to-be-reserved constituencies.

[10]It is possible that to-be-reserved constituencies would have significantly more or fewer minority candidates. Unfortunately, the SC/ST status of candidates in unreserved constituencies only appears in the data from 2004. The state of Karnataka has caste data for candidates from 2004 onwards. 9% of candidates in to-be-reserved constituencies were SCs, versus 5% in never-reserved constituencies. The difference is not significantly different from zero.

1.7 Results: Aggregate

1.7.1 Basic Results

In Table B.4 I present the results from estimating equation 1.1. From Panel A of column 3 of Table B.4, turnout in reserved constituencies after treatment drops by 6 percentage points relative to a baseline of 69 percentage points i.e. turnout falls by 9%. This result is robust to district fixed effects and a set of controls including average female literacy in 2001 and average 2001 unemployment. Turnout is positively correlated with the POST dummy i.e. being in a year after treatment, but the effect is small and the partial effect of reservation is still large, negative and significant.

As we see from columns 3 and 4 of Panel B of Table B.4, being in a reserved constituency after treatment has a positive correlation with the ratio of candidates to electors: being in a reserved constituency after reservation causes the ratio of candidates to electors to rise by 8%. The effect is not precisely estimated, but reservation has no discernible negative impact on this measure of electoral competition.From Panel C of Table B.4, being in a treated constituency after reservation is positively correlated with the margin of victory: the point estimate is 3 percentage points relative to a baseline of ten percentage points. However, the effect is imprecisely estimated[11]. As we see from Panel A of Table B.5, the probability that the winning candidate is from a right-wing party is 26% higher in a reserved constituency after reservation. Suggestively, the probability of victory of ”lower-caste” parties is lower in the treated sample after treatment (as we see in Panel C), but the effect cannot be disentangled from mean reversion.

There is also the question of exit: to argue that reservation causes turnout to drop, we ought also to consider the reverse: whether turnout rises when a constituency always reserved for SCs gets unreserved. Table B.6 considers constituen-

[11] As I outlined earlier, owing to their concentration, the sample of constituencies that are narrowly reserved or left unreserved for STs is very small, so the presence or absence of effects is difficult to argue. However, while widening the cutoff to 5 or 10 percentage points has no large impact on the size of the effect of SC reservation on turnout, the point estimates of the difference-in-difference in ST constituencies (not reported) is consistently small and not significantly different from zero

cies unreserved (with control group identified as in Section 1.4), and shows that turnout rises by 4 percentage points (relative to a baseline of 67 percentage points). The ratio of candidates to electors rises by 43% (whereas in constituencies newly reserved for SCs, the impact on this measure of electoral competition is not different from zero), while, as with constituencies newly SC-reserved, dereservation is not associated with a significant change in the margin of victory.

The bottom panel considers the fraction of winning candidates coming from right-wing, left-wing and lower-caste parties in constituencies newly reserved and newly-unreserved. While right-wing candidates make up a significantly higher fraction of winners in newly-reserved constituencies, no group seems to win significantly more often in newly-unreserved constituencies.

1.7.2 Robustness Checks

In this section I consider relaxing some of the restrictions in my specifications. Currently, constituencies are categorized as treated or untreated if their SC population is within 3 percentage points above or below the district cutoff described in Section 1.4; the choice of specification leaves room for the possibility that some districts will have only treated or untreated constituencies. Further, there are concerns endemic to work using Difference-in-Difference specifications: serial correlation of standard errors, prior trends and possible endogeneity of treatment (Bertrand, Duflo, and Mullainathan (2004)). The dependent variables that I examine (turnout, electoral competition and the probability of success of right-wing parties) are quite likely highly subject to serial correlation. However, in my data at present the time-series dimension is less likely to be an issue: for each constituency, I consider the election period prior to reservation, and the election year after reservation. The method of selection of control groups also indicates that endogeneity of treatment is less likely to be a concern. Furthermore, work examining Delimitation indicates that constituency boundaries, where redrawn, were done so solely in order to ensure equal electorate sizes, with no evident bias, partisan or otherwise (Iyer and

Shivakumar (2009)). This leaves the matter of prior trends.

1.7.2.1 Placebo Checks

Table B.7 presents results for turnout, the ratio of candidates to electors and the margin of victory for the sample, but as though reservation were carried out in 1998 rather than 2008. Since for 5 constituencies no analogue exists prior to 2001, I present my main results with and without these constituencies (columns 1 and 2 respectively). Column 3 runs a placebo for the main specification and illustrates that being in a treated constituency after 1998 has no significant impact on turnout or electoral competition. This may go some way toward allaying concerns of prior trends.

Table B.8 indicates that the results suggesting that right-wing parties win disproportionately often in newly-reserved constituencies is not echoed in the sample constituencies with a placebo treatment carried out one decade prior to reservation.

1.7.2.2 Widening the sample

The results in Table B.4 are also robust to widening the sample to include hitherto-unreserved constituencies with an SC population within 5 percentage points of the district cutoff(see B.9) [12].

1.7.2.3 Districts with both Treated and Untreated Constituencies

In Table B.10, I restrict the sample to only districts which have both treated and untreated constituencies. This constraint, perhaps unsurprisingly, is hard on the data: almost half the observations are lost, leaving 120 observations. The main results are left unaffected, however: turnout falls by 5% in reserved constituencies after reservation, and the ratio of candidates to electors is positively correlated with being in a reserved constituency after reservation. So, too, is the margin of victory, but the point estimate is small and the impact is not significantly different from zero (see B.10).

[12] I am left with very few observations if I tighten the sample to only those constituencies within 1 percentage point of the district cutoff. However, the magnitude of effect is very similar.

1.8 Individual-level Voting

In this section I present individual post-poll survey data for 15 constituencies in one state in the sample. In 2008, an organisation called Lokniti carried out surveys for a random selection of constituencies after the 2008 State Legislative Assembly Elections, on behalf of the Centre for the Study of Developing Societies (CSDS). Respondents were asked whether they voted in the most recent legislative assembly elections (in 2008), whether they voted in the prior elections (in 2004), as well as about current literacy, asset ownership, gender and ethnic group (religion, subcaste and classification into SC, ST or otherwise).

Karnataka has 224 constituencies in the state legislative assembly, of which Lokniti polls 75. Within these constituencies, I look for those meeting the criteria specified in 1.4. This leaves me with 15 constituencies, of which 6 were reserved for the first time in 2008, and 9 remain unreserved.

I regress the probability of voting (VOT) for individual i in constituency c in year y on the incidence of being in a constituency reserved in 2008 (RE) after reservation ($POST$) and their interaction; and the effect of being female and/or a minority and being in a reserved constituency after treatment ($ID \cdot RE \cdot POST$). I estimate the following equations (in spirit very similar to the previous specification):

$$VOT_{icy} = \hat{\alpha}_0 + \hat{\alpha}_1 RE_c + \hat{\alpha}_2 POST_y + \hat{\alpha}_3 RE_c \cdot POST_y + e_{icy} \qquad (1.2)$$

$$\begin{aligned} VOT_{icy} = {} & \hat{\beta}_0 + \hat{\beta}_1 RE_c + \hat{\beta}_2 POST_y + \hat{\beta}_3 RE_c \cdot POST_y + \hat{\beta}_4 ID_{ic} + \\ & \hat{\beta}_5 ID_{ic} \cdot RE_c + \hat{\beta}_6 ID_{ic} \cdot POST_y + \hat{\beta}_7 ID_{ic} \cdot RE_c \cdot POST_y + u_{icy} \end{aligned} \qquad (1.3)$$

1.8.1 Summary Statistics for Lokniti Constituencies: Respondent Characteristics in 2008

I filter out respondents who cannot remember whether they voted in 2008 or 2004, as well as respondents who were too young (or otherwise ineligible) to vote in 2004 or 2008. This leaves me with 405 respondents from treated constituencies, and 497 from untreated constituencies. As we see from Table B.11, untreated and treated constituencies do not vary significantly across a range of respondent characteristics: the fraction of SC respondents in treated constituencies is 16% and 15% in untreated constituencies; the fraction of all sizable minorities (SC/ST/Muslim/Christian) is 29% in treated constituencies versus 33% in untreated. Women make up 49% of respondents in treated constituencies versus 42% in untreated constituencies (not significantly different at 10%). Literacy, monthly income and assets ownership too did not vary significantly across treated and untreated constituencies. One-fifth of those polled in untreated constituencies (16% in treated constituencies) responded "Never"to the questions "How often do you read the newspaper?";"How often do you listen to the news on radio?"and "How often do you watch the news on television?", but the difference between treated and untreated constituencies was small.

Since we are left with 6 reserved and 9 unreserved constituencies, it is difficult to argue that there are or are not systematic differences between the treated and control group. However, village-level averages from the 2001 Census (out of 1420 villages across treated constituencies and 1827 in untreated constituencies) indicate that to-be-reserved constituencies have an SC population of 25% as opposed to 21% in untreated constituencies (see Table B.12), and an ST population of 6% versus 8% in untreated constituencies, but the difference is not significant. The only characteristic which varies significantly across treatment and control groups is the female population, and even there the difference is small: 50% in treated versus 49% in untreated constituencies. Similarly, since the number of candidates is small for this reduced sample, it is difficult to confidently argue that the groups are or are not identical. As Table B.13 indicates, reservation leaves 52 candidates in constituencies reserved in 2008, 59 for those remaining unreserved. It should be noted, though, that 7 candidates out of 52 in to-be-reserved constituencies were SC, versus 3 out of 59 in never-reserved constituencies. The fraction of candidates from various party types does not vary considerably across treatment and control groups.

1.8.2 Results: Individual Voting Data

Table B.14 presents results for the Linear Probability Model and Probit estimates of equation 1.2 to 1.3[13]. From column 2 , it appears that the probability of voting falls in reserved constituencies after reservation relative to the baseline, by about 4% on average, although the effect is imprecisely estimated. From columns 4 and 5, we see that female voters are 13% (in the Probit specification) to 15% (in the LPM specification) less likely to vote in reserved constituencies after treatment relative to the baseline. Columns 6 to 9 each have different definitions of the term "minority". Columns 6 and 7 examine the impact of being an SC or another minority and interacting that with the incidence of being in a reserved constituency after reservation, and columns 8 and 9 lump together any individual who is not an upper-caste Hindu. Minorities are between 9% (as in columns 8 and 9) and 20% (as in columns 6 and 7) less likely to vote in reserved constituencies after treatment, with the baseline group of local elites showing no significant change in voter participation. Columns 10 to 13 discuss the effects of controlling both for being female and in a reserved constituency after treatment, and belonging to a minority group and being in a reserved constituency after treatment. The base group (of male elites) shows no significant difference in voter participation, while being female reduces voter participation by about 15% relative to the baseline, and belonging to a minority community reduces voter participation between 10% (as in columns 12 and 13) and 20% (as in columns 10 and 11).

The data used is taken from a survey in 2008 asking only one retrospective ques-

[13]Since reservation is at the constituency level, and there are only 15 constituencies in the sample, clustering standard errors at constituency level seems problematic. However, the following results are qualitatively very similar using robust standard errors or a block bootstrap approach. I present here the most conservative of my observed results.

tion. This is not so much a concern for intrinsic characteristics such as gender or ethnic group, but controls such as monthly income, asset ownership and years of education do vary over time. However, it seems reasonable to assume that a respondent who was illiterate in 2008 was similarly so in 2004. Columns 14 and 15 of table B.14 suggest that illiterate respondents in treated constituencies in 2008 were 5 % less likely to vote. The effect, however, is imprecisely estimated.

Columns 16 and 17 of table B.14 suggest that uninformed respondents (who responded "never" to how often they consumed news in various media) in treated constituencies in 2008 were not significantly less likely to vote than informed counterparts. However, respondents were asked about their information acquisition in 2008 only.

1.8.3 Magnitude of Effects

"Back-of-the-envelope"calculations suggest that in the Probit estimation (specification as in column 5), the predicted probability that the base group of males votes in a reserved constituency after reservation is 94%, whereas that of females is 72%. Using a similar procedure, we see that being in an SC constituency immediately after reservation does not affect the participation of the base group of elites, while being a minority lowers participation by 14% (columns 7 and 9). In column 11, being female in a treated constituency after treatment reduces an agent's probability of voting by 18%, and the reduction is by 19% in column 13. In column 13, being a minority reduces voter participation in a treated constituency after treatment by 9% and in column 11, by between 9% and 12%. Controlling for being a minority in a treated constituency after treatment, being female reduces participation by between 30% and 32% in column 11 and 31% in column 13. Controlling for being female in a treated constituency after treatment, being a minority reduces voter participation by between 26% and 30% in column 11 and 22% in column 13. From Table B.14, one sees that these magnitudes are qualitatively similar to (though usually bounded below by) those in the LPM specifications.

1.8.4 Interpretation

I consider possible interpretations of the results in Table B.14, and relate them to the theoretical predictions regarding turnout in Section 1.2.3.

1.8.4.1 Competition

From Section 1.2.3.1, we should expect that if reservation affects turnout through its impact on competition, we should expect electoral competition and turnout to go in the same direction.

Since electoral competition (as measured by the margin of victory or ratio of candidates to electors) did not significantly alter as a result of reservation, this does not seem the best explanation.

1.8.4.2 Expressive Voting

From Section 1.2.3.2, were this to be the explanation, we would see participation drop across all ethnic groups, including those of local elites.

Represented minorities, however, show no significant change in voting behaviour, and neither do nonminority voters, the latter result ruling out at least a simple disenfranchisement explanation.

1.8.4.3 Information

From Section 1.2.3.3, if reservation affects turnout primarily through its impact on information, one would expect uninformed voters to disproportionately participate less after reservation.

Although respondents who were "uninformed"in 2008 did not vote significantly less as a result of reservation, it is still suggestive that women and minorities are significantly likelier to respond that they never get the news (through any medium). 28% of female voters (as opposed to 10% of male voters) were "uninformed"i.e., in 2008, responded that they never read newspapers, listened to the news on the radio, or watched it on TV. Respondents who were female, or belonged to a minority, were uninformed by this definition 26% of the time, whereas male nonminority respondents were only uninformed 12% of the time, the difference statistically significant. If candidate ethnic group is a proxy for information about candidate characteristics,it is quite possible that if all candidates share the same broad ethnic group, a major source of information is lost.

1.9 Conclusion

This paper joins the debate on the merits of political reservation with a note on its impact on political participation and electoral competition, and does not support claims that mandated minority representation reduces competition. However, voter participation drops in constituencies with restricted candidate identity. Evidence from a subsample indicates that mandated minority representation may reduce participation for women and for minority groups.

Further work will consider testing for common trends using previous Census data for the sample constituencies. It would also consider sample extension, since five other states carried out elections in 2011. Four of these states are the populous Assam, Tamil Nadu, Kerala and West Bengal. The wider sample (once released) may enable us to observe the impact of reservation of constituencies for Scheduled Tribes, a task so far rendered impossible by the limitations of the existing sample. In addition, the most recent round of delimitation took place in 2008, so I can only observe constituencies immediately after treatment, and for one election year immediately prior to treatment. Further work would examine whether the impact on turnout that I observe continues. Lastly, a theoretical extension might look at the impact of electoral systems: for instance, how does the First-Past-the-Post FPTP system affect this outcome, as opposed to Proportional Representation?

Chapter 2

Why do Workers Remain in Low-Paying Hereditary Occupations?

2.1 Introduction

Occupational rigidity has appeared in various forms all over the world, from guilds in Mediaeval Western Europe to the caste system in India. These systems differ along several dimensions, but they share the following features: recruitment into occupations happens early (in the case of the caste system, at birth) and workers remain in hereditary occupations, even when pay is low.

The case of the Indian caste system in particular has received a great deal of attention, not least because of its persistence. Many persuasive theories have been propounded to explain intergenerational occupational rigidity, ranging from the difficulty of acquiring the human capital required to switch jobs (Bannerjee and Newman (1993)), to the role of caste groups in minimizing information asymmetries (Akerlof (1976), Greif (1993)) and thus lending themselves to contract enforcement (Freitas (2006)) or social insurance (Munshi and Rosenzweig (2009)).

This paper suggests that, in environments with limited or no contract enforcement or insurance provision, occupational (or spatial) mobility is limited by the insurance-provision function of networks- in the case of this paper, that of the family. While occupational specialization by community (the caste, or *jati*[1], in India, in

[1]The *jati* refers to a subcaste rather than a caste, which is usually considered the relevant unit in the literature.

particular) has been studied before (Akerlof (1976), Akerlof (1980)), this paper suggests that insurance can generate intergenerational occupational rigidity(which is frequently conjectured (Freitas (2006)) or assumed (Greif (1993)), but so far has not been explicitly derived), as well as occupational specialization.

I use a two-period Overlapping Generations model in which a parent with an endowment of occupation-specific human capital transfers costly human capital to her offspring, in return for full insurance if the parent suffers an accident. If the offspring participates in the arrangement and insures her parent in case of an accident, she can use the human capital passed on to her by her parent in the final period of her life. If she defaults, she cannot use this and she and her descendants are barred from the insurance arrangement.

I find that agents with low levels of human capital are more likely to participate in the insurance arrangement, since their costs of training their offspring are lower. As the cost of sickness rises, parents are willing to disseminate higher amounts of specific human capital, and the highest sustainable human capital transfer rises with the cost of sickness.

This paper unites two broad views of caste: a "functional"view, suggesting that guilds, castes or professional associations are designed to protect intellectual property or rents of any kind, and that of castes or trading associations as a corrective of information-related market failures. The existing literature on castes as contract-enforcement mechanisms or insurance providers tends to ignore this role, but there is considerable evidence that castes functioned as professional associations. For one thing, as with guilds, many caste surnames reflect ancestral occupations. Castes were largely ascriptive as early as 303 B.C. (Blunt (1969)), and Indian mythology contains several intriguing accounts of the role of the divine order in protecting proprietary knowledge. For instance, one account of the first of the ten incarnations of the preserver, Vishnu, begins with the theft of metaphysical knowledge from the mouth of a sleeping Creator. The preserver, Vishnu, must retrieve the knowledge before those who are not entitled to it can use it.

This paper complements an extensive literature on occupationally-specialized networks, from studies of the guild economy in mediaeval and early modern Europe (Ogilvie (2004)) to Colonial and modern India (Buhler (1886)), (M.N.Srinivas (1962)). The Indian caste system has attracted much attention owing to its centrality in Indian politics (some of which is addressed in Chapter 1), the range of forces used to change it, either legislative or economic, and its resilience in the face of these forces.

Recent work by Banerjee, Bertrand, Datta, and Mullainathan (2009) examines labour-market discrimination in the technology industry on the basis of caste and religion, and finds no significant evidence of discrimination against lower-caste applicants. Bertrand, Hanna, and Mullainathan (2010) find that affirmative action in education does not seem to adversely affect the perception of beneficiaries. However, endogamy seems to be more stubborn: Banerjee, Duflo, Ghatak, and Lafortune (2009) show that a preference for partners of the same community persists even despite urbanisation and economic growth.

There has long been an interest in the benefits of seemingly autocratic and inefficient institutions- from labour market access (Munshi and Rosenzweig (2006), Luke and Munshi (2006)) to access to credit and insurance (Munshi and Rosenzweig (2009), Townsend (1994), Chiappori, Samphantharak, Schulhofer-Wohl, and Townsend (2011), Berman (2000)). A key part of these benefits comes from the role of networks in enforcing co-operation absent formal contract enforcement (Akerlof (1976), Akerlof (1980), Freitas (2006) and Greif (1993)). See also the literature on group lending with joint liability (Ghatak and Guinnane (1999), Ghatak (1999)).

It has also been understood that contractual responsibilities can be passed intertemporally, from generation to generation (for instance, Eswaran and Kotwal (1985) indicates that labour contracts pass from father to son). While discussing the Maghribi mercantile trading association of the mediaeval Middle East, Goitein (1973) observes that sons followed their father's occupations, and further defaults or obligations were transferred to relatives or offspring (Goitein (1978)).

This paper belongs to the broader literature on the persistence of archaic institutions, with a particular emphasis on the relationship between dynastic human capital and the provision of insurance.

The remainder of the paper is organized as follows. Section 2.2 provides some brief background regarding hereditary occupations and the caste system, as well as the Indian "joint family"(in which an extended family lives under the same roof) and norms dictating parental care. Section 2.3 considers alternative explanations of the phenomenon of extended families. Section 2.4 provides a simple model of insurance in which an agent transfers costly human capital to her offspring in return for insurance in the event of an accident. Section 2.4.2 derives predictions for the maximum human capital transfer that a parent is willing to make, and Section 2.4.3 shows the child's problem, with Section 2.4.3.1 deriving predictions for the minimum human capital transfer that a child is willing to accept for an interior solution. Section 2.5 shows results for a numerical simulation of the baseline model. Section 2.6 concludes with some ideas for further work.

2.2 Background

2.2.1 Caste in India: Ascriptive or not?

The word "caste" comes from the Portuguese word "casta", meaning mould, breed or race. The definition of what constitutes a "caste" has mutated considerably, but for the most part it is taken to mean an endogamous group of people who observe (with varying degrees of strictness) rules pertaining to food, drink, work (on which more later) and association with each other and those of other groups.

There is some doubt as to whether castes were designed primarily as units of occupational specialization. Rules 96-99 of Chapter X of the Laws of Manu (Buhler (1886)) are explicit about the dangers of assuming the functions of those castes higher than one's own: "A man of low caste who through covetousness lives by the occupations of a higher one, the king shall deprive of his property and banish. It is better (to discharge) one's own (appointed) duty incompletely than to perform completely that of another; for he who lives according to the law of another (caste) is instantly excluded from his own".

However, rules 80-95 suggest that there is some latitude, provided that certain "polluting"occupations are avoided. "Among the several occupations the most commendable are, teaching the Veda for a Brahmana, protecting (the people) for a Kshatriya, and trade for a Vaisya. But a Brahmana, unable to subsist by his peculiar occupations just mentioned, may live according to the law applicable to Kshatriyas; for the latter is next to him in rank. If it be asked, 'How shall it be, if he cannot maintain himself by either (of these occupations?' the answer is), he may adopt a Vaisya's mode of life, employing himself in agriculture and rearing cattle. But a Brahmana, or a Kshatriya, living by a Vaisya's mode of subsistence, shall carefully avoid (the pursuit of) agriculture, (which causes) injury to many beings and depends on others..... If he applies sesamum to any other purpose but food, anointing, and charitable gifts, he will be born (again) as a worm and, together with his ancestors, be plunged into the ordure of dogs. By (selling) flesh, salt, and lac a Brahmana at once becomes an outcast; by selling milk he becomes (equal to) a Sudra in three days. But by willingly selling in this world other (forbidden) commodities, a Brahmana assumes after seven nights the character of a Vaisya.... A Kshatriya who has fallen into distress, may subsist by all these (means); but he must never arrogantly adopt the mode of life (prescribed for his) betters".

However, occupational specialization and intergenerational occupational rigidity are frequently associated with castes, and there is considerable evidence that castes functioned as professional associations, in which recruitment happened at birth. Blunt (1969) notes that Megasthenes, on a visit to India in 303 B.C, observed that "No one is allowed to marry out of his own caste, or to exchange one profession or trade for another, or to follow more than one business".

2.2.2 The Joint Family

Almost three quarters of all the rural elderly in India live with their children, and it is understood that responsibility for the care of an ailing and aged parent falls to the child. Karve (1953) suggests that even in 1000 B.C., the joint family ("a group of people who generally live under one roof, who eat food cooked in one kitchen, who hold property in common, participate in common family worship and are related to one another as some particular type of kindred.") existed in a similar form to that understood today. Members of the same extended family frequently live in the same residence. Karve (1953) notes that parents lived with married sons, and up to four generations lived under the same roof.

2.2.2.1 Filial Responsibility

Cultural norms dictate that responsibility for caring for the elderly parent rests with the (usually male) child. Primary Vedic texts state, for instance, "Matru Devo Bhava", "Pitru Devo Bhava", which mean "venerate your mother and father as you would God". Chapter 8 of the Mahanirvana Tantra (or "Spiritual System of Great Liberation"), from a translation by Woodroffe (1976) states that "The man who, to the deprivation of his elders ....., fills his own belly is despised in this world, and goes to Hell in the next"; "He who becomes an ascetic, leaving mothers, fathers, infant children, wives, agnates and cognates, is guilty of a great sin"; "The body is nourished by the mother. It originates from the father. The kinsmen, out of love, teach. The man, therefore, who forsakes them is indeed vile".

In Chapter III of the Laws of Manu (translation by Buhler (1886)) is prescribed the banning from sacred rituals "he who forsakes his mother, his father or teacher" (Rule 157) and "he who wrangles or goes to law with his father" (Rule 160). Further, in Chapter XI, the sins leading to a loss of caste include "casting off ones teacher, mother, father, or son.... selling... one's wife, or child... casting off a relative". This is a serious penalty, as it means not only social ostracism for the offender, but also an inability to practise his occupation.

There were also sanctions against travel, particularly foreign travel. Interestingly these seemed to apply to agents from higher rather than lower castes. Hutton (1961) notes that ”One restriction on Hindus.....applies, or used to apply, with much greater force to higher than to lower castes, and that is the prohibition against going overseas”. Insofar as high-caste agents may be said to have higher human capital than lower-caste agents, this may reflect stronger attempts to preclude parental abandonment by children with substantial human capital.

2.2.2.2 Parental Responsibility

On parental duties Chapter 8 of the Mahanirvana Tantra says of the householder: “A father should fondle and nurture his sons until their fourth year, and then until their sixteenth they should be taught learning and their duties”. This rather milder injunction seems born of greater anxiety regarding filial misbehaviour than that of parents. One explanation for this is that parents are altruistic towards children and not *vice versa*, and another is that children could commit less to caring for parents than the other way around.

In the following section, I lay out a simple model of insurance in which agents accumulate human capital to transmit to their offspring in return for care in the event of sickness. But first I consider in more detail some alternative explanations of the phenomenon of filial responsibility for parental care in developing countries.

2.3 Altruism, Asset Poverty or Insurance

One simple explanation for the coresidence of elderly parents with children is that of altruism: i.e. parents wish to maximize their children’s utility and children care about their parent’s utility. However, were this the case, it is difficult to explain retention of children in low-paying hereditary occupations[2]. Moreover, there are documented instances of recent abandonment of or cruelty towards aging parents, leading the Parliament of India to pass the “Maintenance and Welfare of Parents

[2]It is also tempting to suggest that there would be no need for specific prescriptions regarding the care of kin if children or parents looked after each other without prompting.

and Senior Citizens Act"in 2007, which creates provisions for the punishment of children who abandon or neglect parents dependant on them.

Another persuasive explanation frequently offered is that of asset-poverty in the presence of indivisible human capital investments and capital market imperfections a la Bannerjee and Newman (1993) i.e. parents and children cannot afford to invest in the human capital necessary to move out of traditional occupations. However, there is evidence indicating that even when parents can afford to give a child costly education, the child expected to care for the parent still remains in the traditional occupation.

2.3.1 Traditional Occupations and Parental Reponsibility

As Munshi and Rosenzweig (2006) show in a study of occupational choice by gender in a community in Western India, it was *male* children who received network benefits and were discouraged from seeking occupational choices that would weaken the network, and who thus could not benefit from the increased return to outside occupational choices, even when the parents could afford to send their daughters to costlier schools with higher wage returns to education.

Part of the common wisdom behind a preference for sons in developing countries like China and India is that responsibility for caring for elderly parents lies with sons, whereas daughters cannot be relied on to look after aged parents (the scriptural prescriptions described earlier apply specifically to *male* householders.). The phenomenon was also observed elsewhere: while discussing the Maghribi mercantile trading association of the mediaeval Middle East, Goitein (1973) observes that fathers regarded sons as their "insurance policies". In India, 60% of elderly people live with *male* children [3].

Thus asset poverty alone cannot explain why children are retained in low-paying hereditary occupations. This suggests a form of intertemporal exchange, in which

[3] Karve (1953) points out that in the south Indian state of Kerala, we observe that married women live with their mothers. We will consider the phenomenon observed in other Indian states of kinship through male ancestors.

dynastic capital is transmitted to the child expected to care for the elderly parent[4].

2.3.2 Family, Caste and Insurance

Finally, in India, especially in rural areas, family networks are still the largest source of insurance (Munshi and Rosenzweig (2009))- informal loans from family members make up a higher fraction of loans than from friends or employers. A commonly cited reason for this is that caste or *jati* networks have informational advantages- I.R.Dave (1976) says of a premodern Indian trading association "[They were] very keen to stick to truth in their dealings". Further, they "seldom borrow[ed] from other than their castemen"(A.J.Saunders (1920–1922)). Hutton (1961), when describing the functions of caste, says that "[an individual caste member's caste] acts as his trade union, his friendly or benefit society, his health insurance, and if need be provides for his funeral".

There is extensive anecdotal evidence suggesting that members of the same caste were in an excellent position to know each other's doings either through frequent social interaction or by living with or in close quarters to each other. Members of the same *jati* traditionally lived in close quarters. As E.R.Leach (1960) notes, "The Brahmans exhibit a high degree of internal interaction and external exclusiveness. As kinsfolk, they invite each other to feasts... initiations, marriage, death and ancestral rites.. Houses are built with walls adjoining; holes in the walls permit women to pass messages to each other. Children are socialized within the street and until the age of five do not mingle with those of other castes".

Assuming that information flows more effectively in small communities, one should expect that (i) as the size of a caste increases, it should split in order to more effectively monitor its members and (ii) as families increase in size, they should split into different units. In Freitas (2006) one sees for South Indian castes between 1823 and 1941 that there is a positive correlation between the number of distinct *jatis* and population size. Anthropological surveys from Karve (1953) suggest that as family

[4]This implies, in turn, that if a parent had more than one *son* the son expected to care for the parent would be likelier to receive ancestral capital.

sizes increase, extended families split and move into different residences. ”Every existing joint family is a piece broken off from a larger unit.” ”the northern family often breaks up at the death of the man who first founded it. When such a family splits and there is partition....into smaller joint families made up of a man, his wife and children , son’s sons and daughters; or a man, his wife and children and a couple of younger brothers who wish to have his protection or who may not be old enough to take care of themselves.”

Rural justice frequently devolves upon Caste Councils or *Jati Panchayats*, who were observed to have an excellent sense of the truth of matters. Hutton (1961) says that “Caste *panchayats* [councils] will generally be very much more likely to know the true facts of offences their castemen have committed than the ordinary law courts are”. He also notes the importance of small localities in the transmission of information: “The caste council can only act for a limited area, an area small enough ... for members of the caste within the area to have some knowledge of each other as a general rule”. Blunt (1969) observes something similar: “There is not one panchayat only to each endogamous group, but one panchayat to each independent local section of the group”.

It seems reasonable to expect, thus, that the dynastic capital transmitted to the child is frequently tied to a specific location, where the social network can relay information about its members.

I propose an explanation that ties together the following observed phenomena: (i) hereditary occupations- specifically those where male offspring use the family’s dynastic capital; (ii) coresidence of parents with sons; (iii) the informational advantages of local, occupationally specialized networks. How did parents induce their children to remain nearby in order to smooth consumption when older? By providing them with training that would be useless if they travelled far away, or remained in the same area without abiding by the terms of the social contract.

To this end, I derive a simple model of insurance in which agents keep children in hereditary occupations by passing on human capital, and in which children remain in hereditary occupations so as to have specific human capital to pass on.

2.4 Model

It is difficult, when drawing on historical records, sociological documents and religious law to make inferences about social practice, to judge the use of assumptions. Does the author stick to only those are assumptions which are directly borne out by the text, or may she use those which are not directly *contradicted* by her sources? Similarly, how is she to use historical record when evaluating her findings?

I will use anecdotal evidence from historical records or anthropological surveys to either back up assumptions (and attempt to make as few as possible assumptions that do not seem directly indicated by accounts of common practice), and to support the claims that I make. A note on my use of scriptural sources: I will frequently be using the existence of prescribed sanctions or punishments in scripture not only as evidence that such activities carried a cost if discovered, but also as evidence that agents had an incentive to misbehave without the threat of a punishment.

2.4.1 Model Setup

In this model, each agent lives and consumes in two periods of life: Child (C) and parent (P). In the first period, the child works for her parent, who gives the child costly human capital which is only valuable if used locally, in return for full coverage if the parent is sick. If the child insures her parent, she can use her human capital as a parent to get insurance from her child. If she does not insure her parent, she is not allowed to use her human capital by the network of practitioners of the same occupation; thus, her human capital is worthless. Further, she is not permitted to use the insurance arrangement.

The model is timed as follows: in Period 1, the parent transfers costly human capital to the child. After the parent makes her choice of human capital transmission, she and her child find out whether the parent is sick and (if the parent chose insurance) the child decides whether to make a transfer to the parent. The parent dies at the end of Period 1.

At the beginning of Period 2, the child is now a parent with her own child. If the parent was sick at the end of Period 1, it is revealed whether the child insured the parent honestly. If she did, she is allowed to use her human capital, and must choose whether to seek insurance by transmitting h'' to her own child, or autarky. If not, she is not allowed to practise the occupation in which she was trained, and is barred from the insurance arrangement. Then the child discovers whether she is sick, and if she has chosen insurance her offspring must choose whether to insure her. The child dies at the end of Period 2.

In each period, the parent has a probability of sickness π. This π is drawn independently in each period. If the agent is sick she incurs a disutility I. If the parent chooses not to get insurance she has the use of the entirety of her human capital $f(h)$. If she chooses to get insurance, the parent with human capital $f(h)$ transfers to her child human capital h' with time cost $c(h')$, yielding human capital worth $f(h')$ to the child. Thus the parent is left with $f(h)(1 - c(h'))$. This time cost captures the idea that training cost increases in not only the value of human capital imparted to the child, but also in the value of the parent's own human capital, which suggests a motive for retention of workers in low-paying occupations.

If the parent does not fall sick the child has the use of human capital $f(h')$ in Period 1 and in period 2. If the parent falls sick and the child insures her parent, she makes a transfer θI when the parent falls sick, leaving the child with $f(h') - \theta I$. $\theta < 1$ i.e. the child's cost of caring for the parent is increasing in, but lower than, the parent's disutility from sickness. If the child insures her parent, she has the use of human capital $f(h')$ in Period 2, otherwise, she cannot practise the occupations in which she was trained and her human capital is worth 0.

A key assumption here is that information flows perfectly within the family, and further that practitioners of the same occupation know with certainty whether the child insured or cheated the parent. This seems reasonable- as Hutton (1961) and others have stated, the *jati* or *biradari* possessed accurate information as to the rights and wrongs of a matter, and of each other's concerns.

The assumption that the child cannot practise her occupation and remain in the area is suggested by the practice of outcasteing unfilial children (Buhler (1886)). As mentioned before, the penalty of outcasteing was indeed the prescribed one for children who neglected their filial duties. Outcasteing can be regarded as either a refusal to let the offender ply her trade, or by imposing sanctions so severe as to nullify the value of her human capital.

I assume that the human capital that the child possesses cannot be used if she migrates- tantamount to saying that she cannot practise her trade where she is not known. Hindu law and custom regarding commensality or trade with *mleccha* or aliens was well understood. Bougle (1971) notes "To eat with, or even in the presence of, a stranger, or worse, to eat food that he has touched, are so many unpardonable sins".

I assume implicitly that agents care only about their own utility- the issue of bequests or a desire to maximize one's descendants' consumption is not addressed here. I abstract from inheritance of property or money in this paper- a parent has only her own human capital to transmit to her child, and her child cannot obtain occupation-specific human capital elsewhere. The only insurance contract I consider currently has full coverage- the child's transfer comprehends the entirety of the parent's disutility owing to sickness. Further, there is no technology, obsolescence of human capital or uncertainty about the value of human capital i.e. agents know that human capital worth $f(h)$ in Period 1 will continue to be so in Period 2.

For analytical convenience, I assume that children have no human capital of their own and that all agents have the same concave (with convex inverse) utility function[5] $u(.)$,$u(0) = 0$. Throughout I assume that agents have the same discount factor, $0 < \beta < 1$. I assume a convex time cost (with a concave inverse) of transmitting human capital $c(h')$, and a weakly concave function of human capital transmitted

[5]This is made for convenience so that we can pin down the minimum and maximum human capital that parents pass on to children. However, this procedure can be done if we assume that agents have perfect information of their descendants' preferences, and that a child's utility function can be expressed as an increasing and monotonic transformation of that of her parent.

(i.e. $f(h') > h'$, $f'(h') > 0$, $f''(h') \leq 0$).

I wish to examine why agents remain in low-paying hereditary occupations, using the lens of occupation-specific human capital as a means of insurance. Thus it is of interest to consider the cost of insurance, and the benefit of insurance over autarky. The first is captured by the time cost of human capital transmission to the child (increasing in the parent's own human capital), and the latter is captured by the cost of sickness- i.e. the disutility I. The following section examines the highest sustainable human capital transfer by the parent as a function of the cost of sickness I and the value of parental human capital h.

2.4.2 The Parent's Problem

In each period, the parent chooses her human capital transfer to maximize her utility, subject to feasibility and the child's incentive compatibility constraint. The parent has two alternatives in the final period of her life: autarky and insurance. Autarky for the parent yields $u(f(h))$ with probability $1-\pi$ and $-I$ with probability π, and choosing insurance yields $u(f(h)(1-c(h')))$.

The parent's surplus over autarky is unambiguously declining in human capital transfer to the child h'. Thus the *maximum* human capital that the parent is willing to transfer to the child is such that she is indifferent between autarky and insurance subject to feasibility i.e.:

$$u(f(h)(1-c(\bar{h}))) = (1-\pi)u(f(h)) - \pi I. \tag{2.1}$$

subject to:

$$\bar{h} \geq 0$$

$$c(\bar{h}) \leq 1$$

i.e.

$$\bar{h} = min\{c^{-1}(1), max\{0, c^{-1}[1 - \frac{1}{f(h)} \cdot u^{-1}((1-\pi) \cdot u(f(h)) - \pi \cdot I)]\}\} \quad (2.2)$$

Where $c^{-1}[1 - 1/f(h) \cdot u^{-1}((1-\pi) \cdot u(f(h)) - \pi \cdot I)]$ is defined, and

$$\bar{h} = 0 \quad (2.3)$$

Otherwise. From this I can derive some baseline predictions regarding the maximum sustainable human capital, namely:

2.4.2.1 Results: Maximum Human Capital Transferred by Parent

Proposition 1. *The maximum human capital that the parent is willing to transfer to her child ($\bar{h}$) is increasing and concave in the disutility owing to sickness (I) .*

Proposition 2. *The maximum human capital that the parent is willing to transfer to her child ($\bar{h}$) is increasing and concave in the probability of sickness (π) .*

From 2.1, one sees that the parent's surplus over autarky rises in π and in I. Intuitively, as the expected cost of sickness rises, ceteris paribus, the surplus to the parent over autarky rises as well i.e. as the disutility from sickness rises, the benefit to insuring rises and the maximum human capital that the parent will impart increases. For a proof, see Sections D.1 and D.2.

Proposition 3. *The maximum human capital that the parent is willing to transfer to her child ($\bar{h}$) is nonincreasing in her own human capital (h) i.e.* $\frac{\partial \bar{h}}{\partial h} \leq 0$.

Intuitively, any increase in the parent's own human capital raises her cost of imparting human capital to her child as well. Thus, ceteris paribus, the maximum human capital that the parent is willing to disseminate cannot be increasing in h. This suggests that parents with lower human capital are likelier to participate in the insurance arrangement. For a proof, see Section D.3.

Note that this along with Proposition 1 suggests that as the cost of sickness rises, parents with higher and higher human capital will choose to participate in the insurance arrangement i.e. as the cost of sickness rises, the benefit to the parent over autarky outweighs her cost of imparting human capital.

Proposition 3 indicates a reason for the retention of workers in low-paying hereditary occupations- as the cost of human capital transmission increases in the training imparted to the child as well as the parent's own human capital, parents with low human capital will impart more training to their offspring.

Were this to be true, one would expect that the dissemination of dynastic capital should be seen primarily in low-human-capital occupations. Anecdotal evidence suggests that kin-based or community-based social or labour networks are indeed more prevalent in such occupations. Several observers have noted that informational networks seem to have greater efficacy among the lower castes. Munshi and Rosenzweig (2006), too, suggest that labour networks are seen more in the case of low-human-capital occupations. The primacy of caste councils in adjudicating disputes in early Modern India seemed "practically confined to the lower castes"(O'Malley (1968)). D.N.Majumdar (1958), in a study of a North Indian village, states that "every caste has its own panchayat, or *biradari*[brotherhood], though this is not as fully recognised among the high castes as it is among the lower castes". Hutton (1961) notes for Northern Indian castes that "..the lower a caste in the social scale, the stronger its combination, and the more efficient its organisation".

The cost is recognized obliquely in scripture as well- men who turn their backs on a life of asceticism forego considerable spiritual benefits, and the benefits are the highest for *Brahmins*, the highest-ranked of the "twice-born "castes. In Chapter II of the Laws of Manu, Rule 249 states that "A Brahmana who thus passes his life as a student without breaking his vow, reaches (after death) the highest abode and will not be born again in this world". If higher-caste agents are considered to have higher human capital, then this might suggest that the costs of assuming the duties of a householder and passing on human capital to one's offspring were considered to increase in parental human capital.

Propositions 1 and 2 suggest that as the cost of sickness increases i.e. the benefit of insurance increases, the highest insurance obtained by the parent will rise comensurately. Propositions 1, 2 and 3 are key to illustrating that the *maximum* sustainable human capital transfer is increasing in the cost of sickness.

Since the transmission of human capital in this environment is done to acquire insurance, this suggests that increased access to alternative means of insurance for the elderly (whether through capital markets or through non-familial social means) should, on average, depress retention of children in hereditary occupations. While it is not explicitly modelled here, since I regard a failure of the child to insure her parent as essentially parental abandonment, care of the parent goes hand-in-hand with living with or near to the parent. Thus one should also expect that an increase in access to insurance for the elderly should depress parent-child coresidence.

In the next section I consider the minimum acceptable human capital transfer by the child.

2.4.3 The Child's Problem

The child has three alternatives over the two periods of her life: insuring the parent and choosing autarky in period 2; insuring the parent and getting insurance from her child by transferring human capital h'' and cheating, or not insuring the parent[6].

Recall that if the parent remains healthy in Period 1, the child has the use of human capital $f(h')$ in both periods of her life. If the parent falls sick and the child insures her, the child has $f(h') - \theta I$ in Period 1 and the use of human capital $f(h')$ in period 2. Thus the present discounted value of insuring the parent in period 1 and choosing autarky next period is:

$$(1-\pi)u(f(h')) + \pi u(f(h') - \theta I) + \beta(1-\pi)u(f(h')) - \beta\pi \cdot I \tag{2.4}$$

[6]Since the child possesses no human capital of her own and her outside option is zero, cheating at least weakly dominates refusing to participate at all levels of human capital. A positive reservation utility can be built in by treating this problem as the child's surplus utility from remaining to insure the parent over leaving to get her reservation utility.

Insuring the parent and getting insurance from her child yields:

$$(1-\pi)u(f(h')) + \pi u(f(h') - \theta I) + \beta u(f(h')(1 - c(h''))) \tag{2.5}$$

If the parent falls sick in Period 1 and the child does not insure her, the child has human capital $f(h')$ in Period 1, but cannot use her human capital in period 2. Thus not insuring the parent yields:

$$u(f(h')) - \beta\pi \cdot I \tag{2.6}$$

The child will insure the parent honestly if the present discounted value of cheating the parent is no higher than the maximum presented discounted value of honestly insuring the parent i.e. if:

$$\begin{aligned} u(f(h')) - \beta\pi \cdot I \quad \leq \quad & max\{(1-\pi)u(f(h')) + \pi u(f(h') - \theta I) \\ & +\beta(1-\pi)u(f(h')) - \beta\pi I, \\ & (1-\pi)u(f(h')) + \pi u(f(h') - I) \\ & +\beta u(f(h')(1 - c(h'')))\} \\ & \forall h'' \leq \bar{h}(h') \end{aligned}$$

The parent chooses h' in each period to maximize her utility, subject to achieving at least her autarky utility, and subject to feasibility and satisfying her child's incentive compatibility constraints i.e.

$$\begin{aligned} U(h') \quad = \quad & \max_{h'} u(f(h(1-c(h')) \\ & +\mu\{u(f(h(1-c(h')) - (1-\pi)u(f(h)) + \pi I\} \\ & +\lambda\{max\{(1-\pi)u(f(h')) + \pi u(f(h') - \theta I) + \beta(1-\pi)u(f(h')) \\ & -\beta\pi I, (1-\pi)u(f(h')) + \pi u(f(h') - I) \\ & +\beta u(f(h')(1-c(h'')))\} - u(f(h')) + \beta\pi \cdot I\} \\ & +\gamma\{h'\} + \delta\{1 - c(h')\} \end{aligned}$$

In order to arrive at a set of sustainable human capital transfers for any cost of sickness I, I assume stationarity and solve for a stationary equilibrium.

Stationary Equilibrium: An equilibrium is defined as a human capital transfer h' in any period at which the parent at least weakly prefers insurance at time cost $c(h')$ to autarky, and the child at least weakly prefers insuring the parent to cheating. Assuming that π evolves independently in each time period and that the distribution of initial parental h is distributed independently of π, we can characterize a set of h' sustainable in equilibrium for each cost of sickness I.

Assuming stationarity, I use the following procedure to characterize a set of sustainable human capital transfers for any I : First, for every value of parental human capital h I find the *maximum* human capital that a parent with human capital h will offer: $\bar{h}$. Next, for every value of the cost of sickness I, I check for $\tilde{h}$ which is the *minimum* human capital transfer[7] at which a child will honestly insure a parent. For any h, this yields $[\tilde{h}, \bar{h}]$. The union of $[\tilde{h}, \bar{h}]$ across all h gives us the set of all sustainable human capital transfers at I.

2.4.3.1 Minimum Human Capital Accepted by Child: Interior Stationary Solution

As derived above, $\bar{h}$ increases with I. Regarding the relationship between $\tilde{h}$ and I, one can say the following:

Proposition 4. *If the constrained first-best was achieved for an interior solution (i.e. at $0 < h' < c^{-1}(1)$), such that the child is indifferent between cheating and honestly insuring the parent and choosing to insure at $h'' = h'$, and if surplus over cheating at $h' = h''$ is nondecreasing in h, $\frac{\partial h'}{\partial I} > 0$.*

Proposition 5. *If the constrained first-best was achieved for an interior solution (i.e. at $0 < h' < c^{-1}(1)$), such that the child is indifferent between cheating and honestly insuring the parent and choosing to insure at $h'' = h'$, and if surplus over cheating at $h' = h''$ is nondecreasing in h, $\frac{\partial h'}{\partial \theta} > 0$.*

[7] I confine attention at first to situations where the child's surplus monotonically increases in h'; otherwise for completeness one considers the *set* of acceptable human capital transfers for the child $[\tilde{h}, \hat{h}]$.

Proposition 6. *If the constrained first-best was achieved for an interior solution (i.e. at $0 < h' < c^{-1}(1)$), such that the child is indifferent between cheating and honestly insuring the parent and choosing to insure at $h'' = h'$, and if surplus over cheating at $h' = h''$ is nondecreasing in h,* $\frac{\partial h'}{\partial \pi} > 0$.

i.e. an increase in the cost of sickness (and thus the cost of caring for the parent) drives up the minimum human capital transfer that she would accept. Note that an increase in the expected cost of sickness (either through increasing the cost of sickness I or the probability of sickness π) reduces the child's period 1 surplus over cheating. While an increase in the disutility owing to sickness reduces the benefit of period 2 autarky (or period 2 cheating), it may also drive up the human capital transfer that the child pays to her own child to get insurance. For a nondegenerate solution, one sees that the reduction in present surplus for the child is sufficient to increase the lowest possible human capital that she would accept to honestly insure her parent. For a proof, see Sections D.4 and D.6. An increase in the cost to the child of insuring the parent (measured by an increase in the disutility owing to sickness I, probability of sickness π and the cost incurred by the child θ) should on average drive up the minimum acceptable transfer. For a proof, see Section D.5.

This suggests, too, that while acting as insurer the child's minimum compensation must rise in the face of a higher expected payout.

In the following section I use numerical simulations to relax the assumption of a constrained first-best nondegenerate solution to the parent's problem.

2.5 Numerical Simulation

I use a numerical simulation primarily to illustrate Propositions 1, 3 and 4, with the added benefit that it allows me to explore the parameter space in more detail.

From Section D.1, it is seen that the *maximum* human capital transferred by the parent is increasing and concave in I. In Section D.4, enforcing a binding constraint for the constrained optimum, one can see that the minimum human capital that a child will accept is nondecreasing in I, where $0 < h' < c^{-1}(1)$, but could be concave or convex in I. Thus, depending on whether the minimum acceptable human capital transfer rises faster or slower than the maximum permitted by the parent, the set of sustainable human capital transfers either expands or contracts with I.

Thus, I allow for either, but use a numerical simulation to illustrate Propositions 1, 3 and 4, showing the set of sustainable human capital transfers as a function of parental human capital h and cost of sickness I. Simulation further allows me to relax the assumption of constrained optimality for a nondegenerate solution, and that the constraint that the child achieves no more than her cheating utility must bind.

2.5.1 Results: Numerical Solution

Following is an illustration[8] of $\beta = 0.5$, $\pi = 0.5$, $\theta = 0.9$, $f(h) = 3h$, $u(.) = ln(1+.)$, $c(h) = h^2$ [9]. I illustrate the results of Propositions 1[10] and 3, and examine Proposition 4[11] allowing for degenerate solutions to the child's problem.

For any given $I \in [0, 0.99]$, I calculate for any parental human capital $h \in [0, 1]$, and any realization of child human capital $h' \in [0, 1]$: first, the surplus over autarky for the parent and next $\bar{h}$ for the parent. This yields, for any I, for any parental human capital h, the *maximum* human capital that a parent will offer.

Regarding the child's problem, I calculate for any human capital $h' \in [0, 1]$, and any realization of child human capital $h'' \in [0, 1]$ the child's Present Discounted Value of not insuring the parent (as in Equation 2.6); her Present Discounted Value of insuring the parent, and choosing autarky in Period 2 (as in Equation 2.4); $\bar{h}$ for the child (calculated as in 2.1) and her Present Discounted Value of insuring the parent and getting insurance from her own child at h'' (from Equation 2.5). This yields, for any cost of sickness I, the *minimum* human capital ($\tilde{h}$) at which the child will honestly insure the parent[12].

[8]Code available from the author on request

[9]The main results hold for $\beta = 0.5$ and $\pi = 0.25$.

[10]The illustration of Proposition 2 is very similar to that of Proposition 1

[11]The illustration of Propositions 6 and 5 are very similar to that of Proposition 4.

[12]I allow for the child's surplus over cheating to increase as well as decrease in her human capital h'. In practice, however, in the simulation the child's surplus was increasing in h'. Thus I present

This procedure generates, for any cost of sickness I, for any parental human capital h, the set of sustainable human capital transfers $[\tilde{h}, \bar{h}]$. The union of $[\tilde{h}, \bar{h}]$ across all h gives us the set of sustainable human capital transfers for any cost of sickness I.

2.5.1.1 Parental Human Capital Transfer

As in Section D.3, given I, $\bar{h}$ **is nonincreasing in** h. This is illustrated for $I = 0.01$ (Figure E.3), $I = 0.5$ (Figure E.4) and $I = 0.99$ (Figure E.5). From Figures E.3 to E.5, it is evident that as I rises, the range of parental human capital h for which the $\bar{h}$ is the maximum possible expands i.e. parents with low levels of human capital are likelier to participate in the insurance arrangement.

As in Section D.1, given parental human capital h, the maximum human capital transferred by the parent ($\bar{h}$) is nondecreasing and concave in I $\forall h$ (Figure E.1, Figure E.2). Further, the upper bound of human capital transfers is increasing and concave in I (Figure E.6). The *lower bound* of $\bar{h}$ across all h is nondecreasing in I (Figure E.7). This suggests that the highest sustainable human capital transfer is nondecreasing in I.

Therefore, agents remain in hereditary occupations in order to acquire specific human capital with which to pay for insurance from their children, and specifically low-paying hereditary occupations since human capital transmission to one's child is too costly otherwise.

2.5.1.2 Human Capital Accepted by Child

The remaining figures show suggestive illustrations of the solution to the child's problem. From Figure E.8, the *minimum* human capital that a child will accept to honestly insure the parent rises with I, even allowing for a non-interior solution to the parent's problem. Further, while I allow for the minimum human capital to be increasing and either concave or convex in I, numerical simulations in Figure E.8 suggest that $\tilde{h}$ is increasing and convex in I.

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here the minimum acceptable human capital for the child.

2.5.1.3 Set of Sustainable Human Capital Transfers

The *union* of $[\tilde{h}, \bar{h}]$ across h can either expand or contract with I. In the accompanying numerical illustration, the largest set of sustainable human capital transfers first expands, then contracts with I. This reflects the fact that $\bar{h}$ is increasing and concave in I, while $\tilde{h}$ is increasing and convex in I. Thus, for small values of the cost of sickness, any increment in the cost of sickness causes a larger increase in the maximum willingness to pay of the parent than of the child, offset at larger values of the disutility owing to sickness I.

2.6 Conclusion

Developing countries have long relied on informal networks to smooth consumption in the event of sickness or aging. As with Munshi and Rosenzweig (2009), these networks limited mobility, and enforced co-operation through participation in activities (such as endogamy or repeated social interactions within a closed network) that would strengthen the ability of the group to punish defaulters.

This paper studies specific human capital provision in exchange for insurance provision, and finds that both occupational specialization and the retention of children in low-paying hereditary occupations can be generated as a result. This suggests a reason for the persistence of ancestral occupations, and in particular for low-paying ones, in the absence of adequate insurance provision.

While the baseline model raises some suggestive points, there are many extensions to consider. The main prediction of this model is that, as alternative means of insurance become available to the elderly, one should observe lower retention of children in ancestral occupations, and lower rates of children coresiding with elderly parents. Further work would seek to empirically examine the impact of an exogenous increase in access to credit and access for the rural elderly.

Currently, this paper assumes that the value of parental human capital remains fixed in perpetuity. Further work would consider allowing some volatility in agent payoffs if the child remains in the ancestral occupation. I would also like to empirically examine the impact of an exogenous and permanent increase in the human capital of the parent on her participation in the insurance arrangement.

This paper assumes that children have no non-specific human capital of their own. Further work would examine the impact on optimal human capital transfers to the child of varying the child's non-specific human capital, and allowing for the child's non-specific human capital to either complement or substitute for the parent's occupation-specific human capital.

Allowing for a child to have its own human capital might raise some interesting questions regarding either the optimum care that a child gives to its parent or the optimum human capital transfer that a parent makes to a child. Currently, I only allow for full coverage in the case of sickness, so the only decision that the child makes is whether or not to care for the parent- the cost of caring for an ailing parent is exogenous. Further work would allow for partial insurance and examine optimal human capital transfers as a function of both the cost of sickness and the child's non-specific human capital.

Further work would also examine the advantages of caste structures versus apprenticeships- specifically, the channel through which information transmission works between members of a family or practitioners of an occupation. A parent may have better information about the type or productivity of her child than of an apprentice, or simply have greater power to punish a defaulting child than an apprentice. Further work would examine whether these two channels generate differential predictions about the optimum human capital transfer and the nature of occupations at which apprenticeships dominate hereditary human capital transfer.

Chapter 3

Has ICT Polarized Skill Demand? Evidence from Eleven Countries over 25 years

3.1 Introduction

The demand for highly skilled workers has risen significantly since the early 1980s across the US, UK and several other countries (Acemoglu and Autor (2010)), and the return to a college education has risen despite the rise in the supply of college-educated workers. The consensus is that technological progress drives this increase in skill demand (Goldin and Katz (2008)), rather than higher trade with low-wage countries, although some recent literature suggests that the role of trade has been understated (Krugman (2008)).

Recent studies have suggested, however, a more complex picture. While the wages of college graduates in the US rose relative to high-school graduates over the past thirty years, those of high-school graduates rose relative to those of high school dropouts rose in the 1980s, but not after (Autor, Katz, and Kearney (2006), Autor, Katz, and Kearney (2008)). At the same time, so-called "upper tail"inequality (i.e. between the 90th and 50th percentiles of the wage distribution) rose over the past thirty years, while "lower tail "inequality rose during the 1980s, but not since. In the UK, we find that middle-skilled occupations have lost relative to high and low-skilled occupations (Goos and Manning (2007)). Similar results have been found in Germany (Spitz-Oener (2006)) and many other OECD countries (Goos, Manning, and Salomons (2009)).

One explanation for this phenomenon is that of "Skill Biased Technical Change"[1], suggesting that new technologies complement highly-skilled workers and thus drive up the demand for them.

Recent work, notably that of Autor, Levy, and Murnane (2003), suggests the more nuanced view that new technologies complement those performing *nonroutine* tasks, and substitute those performing *routine* cognitive tasks. Many non-routine cognitive tasks (e.g. surgery, consulting or academia) are performed by highly educated workers, while many routine cognitive tasks (e.g. clerical) were performed by middle-skilled workers, who were gradually replaced by ongoing computerization. Low-skilled workers frequently perform non-routine manual tasks (e.g. janitorial work). Routine manual tasks performed by low-skilled workers (e.g. assembly-line manufacturing) dropped out of the pictures after the 1970s, and so the greatest gains were experienced by the highly-skilled group, and the greatest loss by the *middle* group.

Using data from the United States Census and the Directory of Occupational Titles, we show first that middle-skilled workers cluster disproportionately in routine cognitive tasks, and low-skilled workers have a high presence in non-routine manual tasks. Then, using the EUKLEMS dataset providing capital accounts and labour disaggregated by education group for a panel of 11 OECD countries (the US, Japan and 9 other OECD countries) over 25 years (1980-2004), show that those industries with the fastest increase in ICT compensation did indeed show the greatest increase in demand for college-educated workers and the greatest fall in demand for middle-skilled workers, consistent with the polarization hypothesis.

This paper is the first to provide direct international evidence that skills-technology

[1]See Bond and Reenen (2007) for a survey. Industry level data are used by Berman, Bound, and Griliches (1994), Autor, Katz, and Krueger (1998) and Machin and Reenen (1998). Krueger (1993), Berman, Bound, and Griliches (1997) and Lang (2002) use individual data.

complementarity benefits highly-skilled workers at the cost of middle-skilled workers, consistent with the polarization hypothesis. Other work has shown a similar substitution (Autor, Levy, and Murnane (2003), Autor and Dorn (2009)) but only for America. Prior to this, Autor, Katz, and Krueger (1998) show that the rise in the use of computers between 1984 and 1993 was correlated to a fall overall in the demand for high-school graduates between 1979 and 1993, but we provide evidence for a panel of 11 countries over a longer time-period.

3.2 Empirical Strategy

We exploit the new EUKLEMS database, which provides data on college graduates and disaggregates non-college workers into two groups: those with low education and those with "middle level" education[2]. For example, in the US the middle education group includes those with some college and high school graduates, but excludes high school drop-outs and GEDs (see Timmer, van Moergastel, Stuivenwold, Ypma, O'Mahony, and Kangasniemi (2007), Table 5.3 for the country specific breakdown). The EUKLEMS database covers eleven developed economies (US, Japan, and nine countries in Western Europe) from 1980-2004 and also contains data on ICT capital. In analyzing the data we consider not only the potential role of ICT, but also several alternative explanations. In particular, we examine whether the role of trade in changing skill demand could have become more important in recent years (most of the early studies pre-dated the growth of China and India as major exporters).

The idea behind our empirical strategy is that the rapid fall in quality-adjusted ICT prices will have a greater effect in some country-industry pairs that are more reliant on ICT. This is because some industries are for technological reasons inherently more reliant on ICT than others. We have no compelling natural experiment, however, so our results should be seen primarily as conditional correlations. We

[2] In the paper we refer to the three skill groups as "high-skilled" (or sometimes as the "college" group), "middle-skilled", and "low-skilled".

do, however, implement some instrumental variable strategies using the industry-specific initial levels of US ICT intensity and/or routine tasks as an instrument for subsequent ICT increases in other countries. These support the OLS results. We conclude that technical change has raised relative demand for college educated workers and, consistent with the ICT-based polarization hypothesis, this increase has come mainly from reducing the relative demand for middle-skilled workers rather than low-skilled workers.

Our approach of using industry and education is complementary to the alternative approach of using occupations and their associated tasks. Goos, Manning, and Salomons (2011), for example, use wage and employment changes in occupations based on task content, for example, to show that "routine" occupations are in decline and that these are in the middle of the wage distribution. In order to examine ICT-based theories of polarization, however, we believe it is important to have direct measures of ICT capital. Such data is not generally available for individuals consistently across countries and years, which is why using the EUKLEMS data is so valuable. As noted above, however, we do use the occupational information to construct instrumental variables for the growth of ICT at the industry level over time.

The paper is laid out as follows. Section II describes the empirical model, Section III the data and Section IV the empirical results. Section V offers some concluding comments.

3.3 Empirical Model

Consider the short-run variable cost function, $CV(.)$:

$$CV(W^H, W^M, W^L; C, K, Q) \tag{3.1}$$

where W indicates hourly wages and superscripts denote education/skill group S (H = highly educated workers, M = middle educated workers and L = low educated workers), K = non-ICT capital services, C = ICT capital services and Q = value added. If we assume that the capital stocks are quasi-fixed, factor prices are exogenous and that the cost function can be approximated by a second order flexible functional form such as the translog, then cost minimization (using Shephard's Lemma) implies the following three skill share equations:

$$\begin{aligned} SHARE^H &= \phi_{HH} \ln(W^H/W^L) \\ &+\phi_{MH} \ln(W^M/W^L) \\ &+\alpha_{CH} \ln(C/Q) \\ &+\alpha_{KH} \ln(K/Q) \\ &+\alpha_{QH} \ln Q \end{aligned}$$

$$\begin{aligned} SHARE^M &= \phi_{HM} \ln(W^H/W^L) \\ &+\phi_{MM} \ln(W^M/W^L) \\ &+\alpha_{CM} \ln(C/Q) \\ &+\alpha_{KM} \ln(K/Q) \\ &+\alpha_{QM} \ln Q \end{aligned}$$

$$\begin{aligned} SHARE^L &= \phi_{HL} \ln(W^H/W^L) \\ &+\phi_{ML} \ln(W^M/W^L) \\ &+\alpha_{CL} \ln(C/Q) \\ &+\alpha_{KL} \ln(K/Q) \\ &+\alpha_{QM} \ln Q, \end{aligned}$$

where $SHARE^S = \frac{W^S N^S}{W^H N^H + W^S N^M + W^L N^L}$ is the wage bill share of skill group S =

$\{H, M, L\}$ and N^S is the number of hours worked by skill group S. Our hypothesis of the ICT-based polarization theory is that $\alpha_{CH} > 0$ and $\alpha_{CM} < 0$ (with the sign of α_{CL} being ambiguous)[3].

Our empirical specifications are based on these equations. We assume that labor markets are national in scope and include country by time effects (ϕ_{jt}) to capture the relative wage terms. We also check our results are robust to including industry-specific relative wages directly on the right hand side of the share regressions. We allow for unobserved heterogeneity between industry by country pairs (η_{ij}) and include fixed effects to account for these, giving the following three equations:

$$SHARE^S = \phi_{jt} + \eta_{ij} + \alpha_{CS} \ln(C/Q)_{ijt} + \alpha_{KS} \ln(K/Q)_{ijt} + \alpha_{QS} \ln Q_{ijt}, \tag{3.2}$$

where i = industry, j =country and t = year. We estimate in long (25 year) differences, Δ, to look at the historical trends and smooth out measurement error. We substitute levels rather than logarithms (i.e. $\Delta(C/Q)$ instead of $\Delta \ln(C/Q)$) because of the very large changes in ICT intensity over this time period. Some industry by country pairs had close to zero IT intensity in 1980 so their change is astronomical in logarithmic terms[4]. Consequently our three key estimating equations are:

$$\Delta SHARE^S_{ijt} = c^S_j + \beta^S_1 \Delta(C/Q)_{ijt} + \beta^S_2 \Delta(K/Q)_{ijt} + \beta^S_3 \Delta \ln Q_{ijt} + u^S_{ijt}. \tag{3.3}$$

In the robustness tests we also consider augmenting equation (3.3) in various ways. Since ICT is only one aspect of technical change we also consider using Research and Development (R&D) expenditures. This is a more indirect measure of task-based technical change, but it has been used in the prior literature, so it could be an important omitted variable. Additionally, we consider trade variables (such

[3]The exact correspondence between the coefficients on the capital inputs and the Hicks-Allen elasticity of complementarity is more complex (see Brown and Christensen (1981)).

[4]The range of $\Delta \ln(C/Q)$ lies between -1 and 23.5. We report robustness checks using $\frac{\Delta(C/Q)}{C/Q}$ as an approximation for $\Delta \ln(C/Q)$.

as imports plus exports over value added) to test whether industries that were exposed to more trade upgraded the skills of their workforce at a more rapid rate than those who did not. This is a pragmatic empirical approach to examining trade effects. Under a strict Heckscher-Ohlin approach trade is a general equilibrium effect increasing wage inequality throughout the economy so looking at the variation by industry would be uninformative. However, since trade costs have declined more rapidly in some sectors than others (e.g. due to trade liberalization) we would expect the actual flows of trade to proxy this change and there to be a larger effect on workers in these sectors than in others who were less affected (Krugman (2008) also makes this argument).

3.4 Data

3.4.1 Data Construction

The main source of data for this paper is the EUKLEMS dataset, which contains data on value added, labor, capital, skills and ICT for various industries in many developed countries (see Timmer, van Moergastel, Stuivenwold, Ypma, O'Mahony, and Kangasniemi (2007)). The EUKLEMS data are constructed using data from each country's National Statistical Office (e.g. the US Census Bureau) and harmonized with each country's national accounts. EUKLEMS contains some data on most OECD countries. But since we require data on skill composition, ICT and non-ICT capital and value added between 1980 and 2004, our sample of countries is restricted to eleven: Austria, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Spain, the UK and the USA[5].

Another choice we had to make regards the set of industries we analyze. Since our baseline year (1980) was close to the peak of the oil boom, we have dropped energy-related sectors - mining and quarrying, coke manufactures and the supply of

[5]In order to increase the number of countries we would need to considerably shorten the period we analyze. For example, limiting our analysis to 1992-2004 (12 years instead of 25) only adds Belgium. To further add Czech Republic, Slovenia and Sweden we would need to restrict the sample to 1995-2004. In order to preserve the longer time series we focused on the 11 core OECD countries.

natural gas - from the sample (we report results that are very robust to the inclusion of these sectors). The remaining sample includes 27 industries in each country (see Table G.10). Wage data by skill category are only reported separately by industry in some countries. We therefore aggregate industries to the lowest possible level of aggregation for which all the variables we use could be constructed with the precise level of disaggregation varied by country (see Table G.11)[6]. Our final sample has 208 observations on country-industry cells for 1980 and 2004. We also have data for intervening years, which we use in some of the robustness checks.

For each country-industry-year cell in our dataset we construct a number of variables. Our main outcome is the wage bill share of workers of different educational groups, which is a standard indicator for skill demand. In 9 of the 11 countries, the high-skilled group indicates whether an employee has attained a college degree[7]. A novel feature of our analysis is that we also consider the wage bill of middle-skilled workers. The precise composition of this group varies across countries, since educational systems differ considerably. But typically, this group consists of high school graduates, people with some college education, and people with non-academic professional degrees.

Our main measure for use of new technology is Information and Communication Technology (ICT) capital divided by value added. Similarly, we also use the measure of non-ICT capital divided by value added. EUKLEMS builds these variables using the perpetual inventory method from the underlying investment flow data for several types of capital. For the tradable industries (Agriculture and Manufacturing) we construct measures of trade flows using UN COMTRADE data[8]. Details are contained in H.2.

Finally, we construct measures of skill and task content by occupation. We begin

[6] Results are robust to throwing away information and harmonizing all countries at the same level of industry aggregation.

[7] In two countries the classification of high-skilled workers is different: in Denmark it includes people in "long cycle" higher education and in Finland it includes people with tertiary education or higher.

[8] Using a crosswalk (available from the authors upon request) we calculate the value of total trade, imports and exports with the rest of the world and separately with OECD and non-OECD countries. We identify all 30 countries that were OECD members in 2007 as part of the OECD.

with US Census micro data for 1980 from IPUMS, which identify each person's education (which we aggregate to three skill levels using the EUKLEMS concordance for the US) and occupation. We then use the "80-90" occupation classification from Autor, Levy, and Murnane (2003) to add information on the task measures they construct. These include routine cognitive tasks (measured using Set limits, Tolerances, or Standards); routine manual tasks (measured using Finger Dexterity); non-routine cognitive tasks measured using both (i) Quantitative reasoning requirements and (ii) Direction, Control, and Planning and non-routine manual tasks (measured using Eye-Hand-Foot coordination). We standardize each of these five task measures by subtracting the mean task score across occupations, weighted by person weights, and dividing the result by the standard deviation of the measure across occupations.

3.4.2 Descriptive statistics

3.4.2.1 The Routineness of Occupations by Skill Level

We begin the description of the data by examining the relationship between education and tasks. Table G.2 reports the top 10 occupations for each of the three education categories using US data for 1980. This table shows that the occupations with the largest shares of highly-educated workers (such as physicians, lawyers and teachers) and those with the highest shares of low-educated workers (such as cleaners and farm workers) have low scores on routine cognitive tasks. These groups also have typically low scores on routine manual tasks. By contrast, occupations with high shares of middle-educated workers (mostly clerical occupations and bank tellers) typically score highly on both routine cognitive and routine manual tasks. Therefore, if the only contribution of ICT was to automate (and replace) routine tasks, it should benefit both high-skilled and low-skilled workers at the expense of middle-skilled workers.

However, as argued by Autor, Levy, and Murnane (2003) information technology should also complement non-routine tasks, especially cognitive ones. Here the picture is more nuanced: high-skilled occupations typically score highly on non-routine cognitive tasks, though not on non-routine manual tasks. Middle-skilled occupations tend to score around average in non-routine tasks, while low-skilled workers score low on non-routine cognitive tasks but above average on non-routine manual tasks. Therefore, to the extent that information technology both replaces routine tasks and complements non-routine tasks, the overall picture suggests that ICT should increase the relative demand for high-skilled workers at the expense of middle-skilled workers, with no clear effect on low-skilled workers.

We further explore the relationship between education groups and tasks in Table G.1, which reports the average tasks content by skill group, again using 1980 US data. On average, high-skilled occupations rank lowest in terms of routine tasks and non-routine manual tasks, but highest in terms of non-routine cognitive tasks, so the Autor, Levy, and Murnane (2003) model suggests that they benefit from ICT improvements. Middle-skilled occupations score above-average on routine tasks and a little below average on non-routine tasks, so ICT should probably reduce the relative demand for their services. Lastly, the picture for low-skilled workers is once again mixed, for both routine and non-routine tasks, so the theory gives no clear prediction on how ICT improvements should affect the demand for their services.

Having discussed the relationship between skills and tasks, we now move on to describe the changes in skill demand using the EUKLEMS data.

3.4.2.2 Cross Country Trends

Panel A of Table G.3 shows summary statistics for the levels of the key variables in 1980 across each country and Panel B presents the same for the changes through 2004. The levels have to be interpreted with care as exact comparison of qualifications between countries is difficult, which is why wage bill shares are useful summary measures as each qualification is weighted by its price (the wage)[9]. The ranking of countries looks sensible with the US having the highest share of high-skilled (29 percent), followed by Finland (27 percent). All countries have ex-

[9]Estimating in differences also reduces the suspected bias from international differences as the definitions are stable within country over time.

perienced significant skill upgrading as indicated by the growth in the high-skilled wage bill share in column (1) of Panel B, on average the share increased form 14.3 percent in 1980 to 24.3 in 2004.

The UK had the fastest absolute increase in the high-skilled wage bill share (16.5 percentage points) and is also the country with the largest increase in ICT intensity. The US had the second largest growth of ICT and the third largest increase in the high-skilled wage bill share (13.9 percentage points), but all countries have experienced rapid increases in ICT intensity, which doubled its 1980 share of value added. Figures F.1 to F.3 show the correlation between the growth of the wage bill share of each of the three education groups and ICT intensity. There appears to be a positive relationship for the highly educated (Figure F.1), a negative relationship for the middle educated (Figure F.2) and no relationship for the least educated (Figure F.3). Although this is supportive of our model's predictions, there are many other influences at the country-level so our econometric results below will focus on the within country, across industry variation.

Returning to Table G.2, note that the change of the middle education share in column (2) is more uneven. Although the mean growth is positive, it is relatively small compared to the highly educated (8.7 percentage points on a base of 51.1 percent), with several countries experiencing no growth or a decrease (the US and the Netherlands).

Moreover, as Figures F.4 to F.5 shows, although the wage bill share of the middle group rose more rapidly (in percentage point terms) between 1980 and 1986, it subsequently decelerated. Indeed, in the last six year sub-period, 1998-2004, the wage bill share of middle-skilled workers actually fell. At the same time, the wage bill share of low-skilled workers continued to decline throughout the period 1980-2004, but at an increasingly slower rate. Figure F.5 shows the US, the technology leader that is often a future indicator for other nations. From 1998-2004 the wage bill share of the middle educated declined more rapidly than that of the low-educated workers. Figure F.5 is in line with the finding that while college educated US workers continued to gain relative to high-school graduates, high-school graduates gained relatively to college dropouts in the 1980s but not in the 1990s (see Autor, Katz, and Kearney (2008)).

3.4.2.3 Cross Industry Trends

Tables G.4 and G.5 break down the data by industry. In levels (Table G.4) the highly educated were disproportionately clustered into services both in the public sector (especially education) and private sector (e.g. real estate and business services). The industries that upgraded skills rapidly (Table G.5) were also mainly services (e.g. finance, telecoms and business services), but also in manufacturing (e.g. chemicals and electrical equipment). At the other end of the skill distribution, the textile industry, which initially had the lowest wage bill share of skilled workers, upgraded somewhat more than other low-skill industries (transport and storage, construction, hotels and restaurants, and agriculture). This raises the issue of mean reversion, so we are careful to later show robustness tests to conditioning on the initial levels of the skill shares in our regressions. In fact, the ranking of industries in terms of skill intensity in 1980 and their skill upgrading over the next 25 years was quite similar across countries. This is striking, because the countries we analyze had different labor market institutions and different institutional experiences over the period we analyze. This suggests something fundamental is at play that cuts across different sets of institutions.

ICT grew dramatically from 1980-2004, accounting for more than 42 percent of the average increase in capital services (see columns (8) and (9) of Table G.5). The increased ICT diffusion was also quite uneven: financial intermediation and telecoms experienced rapid increases in ICT intensity, while in other industries, such as agriculture, there was almost no increase.

Figures F.6, F.7, F.8, F.9, and F.10 and F.11 plot changes by industry in the wage bill shares of high, medium, and low-skilled workers, respectively, against changes in ICT intensity. The top panel (A) of each figure includes all industries with fitted regression lines (solid line for all industry and dashed line for non-traded sectors only). The bottom panel (B) restricts attention to the traded sectors. Figure F.6 shows that the industries with the fastest ICT upgrading had the largest increase in the high-skilled wage bill share. One might be worried that two service sectors, "Post & Telecommunications" and "Financial Intermediation", are driving this result, which is one reason Figure F.7 drops all the non-traded sectors. In fact, the relationship between high-skilled wage bill growth and ICT growth is actually stronger in these "well measured" sectors.

Figures F.8 and F.9 repeat this analysis for the middle educated groups. We observe the exact opposite relationship to Figures F.6 and F.7: the industries with the faster ICT growth had the largest fall in the middle-skilled share whether we look at the whole economy (Figure F.8) or just the traded sectors (Figure F.9). Finally, Figures F.10 and F.11 show that there is essentially no relationship (Figure F.10) or a mildly positive one (Figure F.11) between the change of the share of the least educated and ICT growth.

These figures are highly suggestive of empirical support for the hypothesis that ICT polarizes the skill structure: increasing demand at the top, reducing demand in the middle and having little effect at the bottom. To examine this link more rigorously, we now turn to the econometric analysis.

3.5 Econometric Results

3.5.1 Basic Results

Our first set of results for the skill share regressions are reported in Table G.6. The dependent variables are changes from 1980-2004 in the wage bill share of the high-skilled in Panel A, the middle-skilled in Panel B and the low-skilled in Panel C. The first four columns look across the entire economy and the last four columns condition on the sub-sample of "tradable" sectors where we have information on imports and exports.

Column (1) of Panel A reports the coefficient on the constant, which indicates that on average there was a ten percentage point increase in the college wage bill share. This is a very large increase, considering the average skill share in 1980 (across our sample of countries) was only 14%. Column (2) includes the growth in ICT capital intensity. The technology variable has a large, positive and significant coefficient and reduces the regression constant to 8.7. Column (3) includes the growth of non-ICT capital intensity and value added. The coefficient on non-ICT capital is negative and insignificant, suggesting that there is no sign of (non-ICT) capital-skill complementarity. Some studies have found capital-skill complementarity (e.g. Griliches (1969)), but few of these studies have disaggregated capital into its ICT and non-ICT components, so the evidence for capital-skill complementarity may be due to aggregating over high-tech capital that is complementary with skills and lower tech capital that is not. The coefficient on value added growth is positive and significant suggesting that skill upgrading has been occurring more rapidly in the fastest growing sectors (as in Berman, Somanathan, and Tan (2005)). Column (4) includes country fixed effects. This is a demanding specification because the specification is already in differences so this specification essentially allows for country specific trends. The coefficient on ICT falls (from 65 to 47) but remains significant at conventional levels[10]

We re-estimate these specifications for the tradable industries in the next four columns. Column (5) shows that the overall increase in the college wage-bill share from 1980-2004 was 9 percentage points - similar to that in the whole sample. Columns (6) - (8) add in our measure of ICT and other controls. The coefficient on ICT in the tradable sector is positive, highly significant and larger than in the overall sample (e.g. 129 in column (8)).

Panel B of Table G.6 reports estimates for the same specifications as panel A, but this time the dependent variable is the share of middle-educated workers. Column

[10]Including the mineral extraction sectors caused the ICT coefficient to fall from 47 to 45. We also tried including a set of industry dummies in column (4). All the variables became insignificant in this specification. This suggests that it is the same industries that are upgrading across countries.

(1) shows that the wage bill share of middle-skilled workers grew by 8.7 percentage points over this time period. But as the rest of the panel shows, the association between the change in middle-skilled workers and ICT is strongly negative. In column (4), for example, a one percentage point increase in ICT intensity is associated with a 0.8 percentage point fall in the proportion of middle-skilled workers. The magnitude of the coefficients for the sample that includes all industries is quite similar to those for college educated workers. Panel C shows that technology measures appear to be insignificant for the least educated workers, illustrating the point that the main role of ICT appears to be in changing demand between the high-skilled and middle-skilled groups[11]. Since the adding up requirement means that the coefficients for the least skilled group can be deduced from the other two skill groups we save space by omitting Panel C in the rest of the Tables.

Overall, Table G.6 shows a pattern of results consistent with ICT based polarization. Industries where ICT grew most strongly where those with the largest shifts towards the most skilled and the largest shifts away from the middle skilled, with the least skilled largely unaffected.

3.5.2 Robustness and Extensions

3.5.2.1 Initial conditions

Table G.7 examines some robustness checks using the results in our preferred specification of column (4) of Table G.6 (reproduced in the first column). Since there may be mean reversion we include the level of initial share of skills in 1980 in column (2). This does not qualitatively alter the results, although coefficient on ICT for the middle-skilled does fall somewhat [12].

[11] The difference in the importance of ICT for the middle and lowest skill groups implies that high school graduates are not perfect substitutes for college graduates as Card (2009) argues in the US context. The majority of our data is from outside the US, however, where there are relatively fewer high school graduates.

[12] As we explain above our specifications assume that markets are national in scope, so that country fixed effects capture changes in relative wages. To further test this assumption we re-estimated columns (1) and (2) in Table 6 with additional controls for the change in the difference in industry specific relative ln(wages) between the high-skilled and middle-skilled and between the high-skilled and low-skilled. The resulting coefficients (standard errors) on our measure of ICT are 41.43 (15.24) and 35.98 (14.82) for high-skilled workers, and -54.38 (20.96) and -33.35 (13.87) for middle-skilled

3.5.2.2 Timing of changes in skills and ICT

One limitation of the specifications that we discussed so far is that the changes on the right-hand side and left hand-side are both concurrent. To mitigate potential concerns about reverse causation, we re-estimate the baseline specification of column (1) Table G.7, where the right hand side variables are measured for the first half of the period we consider (1980-1992) and the left hand side variable is measured for the second half of the period (1992-2004). The estimated coefficients (and standard errors) on changes in our measure of ICT are 52.62 (23.53) for high-skilled workers and -52.52 (28.97) for middle-skilled workers. These results are almost unchanged (51.31 (22.65) and -58.22 (22.99) respectively) when we instead use the equivalent of the specification in column (2) of Table 6.

3.5.2.3 Heterogeneity in the coefficients across countries

Wage inequality rose less in Continental Europe than elsewhere, so it is interesting to explore whether technological change induced polarization even there. Columns (3) and (4) of Table G.7 restrict the sample to the 8 Continental European countries (Austria, Denmark, Finland, France, Germany, Italy, Netherlands and Spain), and the results are similar to those in the full sample of countries. For example, column (5) shows that the correlation between ICT and polarization is larger for the US than for the full sample, though column (5) shows that the estimates become imprecise when we control for baseline levels of skill composition. The sample size for most individual countries is rather small, but if we re-estimate the specification of Table G.7 column (2) separately country by country we obtain negative coefficients on ICT for all 11 countries for medium skill shares and positive coefficients for 10 countries for the high skill shares (Japan is the single exception)[13]. The results are also robust to dropping any single country[14].

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workers.

[13]The mean of the 11 country-specific coefficients on ICT is very similar to the pooled results (-112 for the middle-skilled share and 71 for the high-skilled share).

[14]For example, we had concerns about the quality of the education data in Italy so we dropped Italy from the sample. In the specification of column (4) of Table G.6, the coefficient (standard error) on ICT capital was 55.2(1.04) for the high education group and -68.54(22.82) for the middle educated.

3.5.2.4 Instrumental variables

One concern is that measurement error in the right hand side variables, especially our measure of ICT, causes attenuation bias[15]. To mitigate this concern, we use the industry-level measures of ICT in the US in 1980 as an instrument for ICT upgrading over the whole sample. The intuition behind this instrument is that the dramatic global fall in quality-adjusted ICT prices since 1980 (e.g. Jorgenson, Ho, and Stiroh (2008)) disproportionately affects industries that (for exogenous technological reasons) have a greater potential for using ICT inputs. An indicator of this potential is the initial ICT intensity in the technological leader, the US. As column (7) of Table G.7 shows, this instrument has a first-stage F-statistic of 10.5, and the sign of the first stage regressions (not reported) is as we would expect, namely industries that were more ICT-intensive in 1980 upgraded their use of ICT more than others. In the 2SLS estimates of column (7) the coefficient on ICT is roughly twice as large as the OLS coefficients for the college educated group (and significant at the 5 percent level), and a little bigger for the middle-skilled group. Column (8) report estimates the same specification but this time excluding the US itself, and the results are very similar. While we acknowledge that estimates using this instrument do not necessarily uncover the causal effect of ICT, it is reassuring that these 2SLS estimates are somewhat larger than the OLS estimates, as we would expect given the likely measurement error.

As a further check, we use the proportion of routine tasks in the industry (in the US in the base year) as an instrument for future ICT growth as these industries were most likely to be affected by falling ICT prices (see Autor and Dorn, 2009). The results of using this instrument are shown in columns (9) and (10). Although the first stages are weaker with this instrument[16], and the 2SLS estimates are not very pre-

[15] Estimates of the ICT coefficient for the two 12-year sub-periods of our data are typically about half of the absolute magnitude of those for the full period. In general, our estimates for shorter time periods are smaller and less precise, consistent with the importance of measurement error in the ICT data. For example, in the specification of column (4) of Panel A in Table G.6, the coefficient (standard error) on ICT was 18.30 (10.30) in a pooled 12 year regression. We could not reject the hypothesis that the ICT coefficient was stable over time (p-value=0.35).

[16] The signs of the instruments in the first stage are correct. The F-test is 6.5 in column (9) compared

cise, these columns again suggest that we may be under-estimating the importance of ICT by just using OLS.

3.5.2.5 Disaggregating the wage bill into wages and hours

The wage bill share of each skill group reflects its hourly wage and hours worked, and those of the other skill groups. We estimated specifications that are identical to those in Table G.6, except that they disaggregate the dependent variable into the growth of relative skill prices and quantities. In the first two columns of Table G.8 we reproduce the baseline specifications using the log relative wage bill (which can be exactly decomposed) as the dependent variable[17]. Columns (1) - (4) confirm what we have already seem using a slightly different functional form: ICT growth is associated with a significant increase in the demand for high-skilled workers relative to middle-skilled workers (first two columns) and with a significant (but smaller) increase for low-skilled workers relative to middle-skilled workers (third and fourth columns).

For the high vs. middle-skill group, ICT growth is significantly associated with increases in relative wages and relative hours (columns (5), (6), (9) and (10)). In comparing the middle vs. low groups, the coefficients are also all correctly signed, but not significant at conventional levels. Overall this suggests that our results are robust to functional form and the shifting pattern of demand operates both through wages and hours worked[18].

3.5.3 Trade, R&D and skill upgrading

Having found that technology upgrading is associated with substitution of college-educated workers for middle-educated workers, we now examine whether changes

to 10.5 in column (7).

[17] Another functional form check was using the growth rate of ICT intensity. For the specification in column (3) of Panel A in Table G.6 we replaced $\Delta(C/Q)$ with $\frac{\Delta(C/Q)}{C/Q}$. The coefficient (standard error) on ICT growth was 2.586 (1.020). The marginal effect of a one standard deviation increase (0.581) is 1.50 (=0.581*2.586), almost identical to 1.55 (=0.024*64.6) in Table G.6.

[18] In examining these results across countries there was some evidence that the adjustment in wages was stronger in the US and the adjustment in hours was stronger in Continental Europe. This is consistent with the idea of great wage flexibility in the US than in Europe.

in trade exhibit similar patterns. The first three columns of Table G.9 suggest that more trade openness (measured as the ratio of imports plus exports to value added) is associated with increases in the wage bill share of college educated workers and declines in the share for middle-skilled workers. However, the when we control for initial R&D intensity the association between trade and skill upgrading becomes smaller and insignificant. Column (4) repeats the specification of column (3) for the sub-sample where we have R&D data and shows that the trade coefficient is robust. Column (5) includes R&D intensity in a simple specification and shows that the coefficient on trade falls (e.g. from 0.50 to 0.24 in Panel A) and is insignificant, whereas the coefficient on R&D is positive and significant. In column (6) we include the changes in the ICT and non-ICT capital stocks and the coefficient on trade is now very small. Column (7) drops the insignificant trade variable and shows that ICT and R&D and individually (and jointly) significant.

We also used the Feenstra and Hansen (1999) method of constructing an offshoring variable and included it instead of (and alongside) trade in final goods. The offshoring variable has more explanatory power than final goods trade[19]. Column (8) includes offshoring ("Imported Intermediate Inputs") into the full sample as it can be defined for all industries. The results suggest a significant positive correlation between offshoring for high skilled workers and a negative but insignificant correlation between ICT and demand for middle skilled workers. Column (9) produces a similar result on the sample of tradable sectors and column (10) includes ICT and R&D. As with the trade measure in final goods, the offshoring coefficient is driven to zero in the final column for the highly educated and remains insignificant for the middle educated. The ICT effects are robust to the inclusion of the offshoring measures.

These findings are broadly consistent with most of the literature that finds that technology variables have more explanatory power than trade in these kinds of skill

[19]For example, in the same specification of column (6) of Table G.9 we replaced the final goods trade variable with the offshoring measure. In the high skilled equation the coefficient (standard error) was 4.27 (2.82) and in the middle skilled equation the coefficient (standard error) was -11.6 (9.87).

demand equations[20]. Of course, trade could be influencing skill demand through affecting the incentives to innovate and adopt new technologies, which is why trade ceases to be important after we condition on technology (e.g. Bloom, Draca, and Reenen (2011), argue in favor of this trade-induced technical change hypothesis)[21]. Furthermore, there could be many general equilibrium effects of trade that we have not accounted for (these are controlled for by the country time effects).

3.5.4 Magnitudes

We perform some "back of the envelope" calculations in Table G.13 to gauge the magnitude of the effect of technology on the demand for highly skilled workers. Column (1) estimates that ICT accounts for 13.2 percent of the increase in the college share in the whole sample without controls and column (2) reduces this to 8.5 percent with controls. Many authors (e.g. Jorgenson, Ho, and Stiroh (2008)) have argued that value added growth has been strongly affected by ICT growth, especially in the later period, so column (2) probably underestimates the effect of ICT. Column (3) reports equivalent calculations for the tradable sectors. Here, ICT accounts for 16.5 percent of the change and R&D a further 16.1 percent, suggesting that observable technology measures by account for almost a third of the increase in demand for highly skilled workers. If we include controls in column (4) this falls to 23.1 percent. Finally, columns (5) and (6) report results for the IV specification for the whole sample, showing an ICT contribution of ICT of between 22.1 percent and 27.7 percent[22].

[20] These are simple industry-level correlations and not general equilibrium calculations, so we may be missing out the role of trade through other routes.

[21] We further test whether the association between trade and skill upgrading remains similar when we examine different components of trade separately. Table G.12 suggests that when we examine imports and exports separately, the picture is quite similar. Greater trade is associated with an increase in the college wage bill share until we control for initial R&D intensity, in which case the coefficient on trade falls and becomes insignificant. Results are similar when we analyze separately imports to (or exports from) OECD countries. For non-OECD countries the results are again the same, except for exports to non-OECD countries, which remains positively associated with changes in the college wage-bill share even after we add all the controls, including R&D. However, it should be noted that the change in exports to developing countries is on average very small.

[22] The IV specifications for tradeables show an even larger magnitude. For example in a specification with full controls, R&D and ICT combined account for over half of all the change in the college wage bill share. The first stage for the IV is weak, however, with an F-statistic of 6, these cannot be

We also note that while ICT upgrading alone should have led to decreased demand for middle-skilled workers. While we do not see such a decrease overall, Figure F.5 shows a slowdown in the growth of demand for middle skilled over time, and a reversal (in other words negative growth) for middle-skilled workers from 1998-2004.

We have no general equilibrium model, so these are only "back of the envelope" calculations to give an idea of magnitudes. Furthermore, measurement error probably means that we are probably underestimating the importance of the variables. Nevertheless, it seems that our measures of technology are important in explaining a significant proportion of the increase in demand for college educated workers at the expense of the middle-skilled.

3.6 Conclusions

Recent investigations into the changing demand for skills in OECD countries have found some evidence for "polarization" in the labour market in the sense that workers in the middle of the wage and skills distribution appear to have fared more poorly than those at the bottom and the top. One explanation that has been advanced for this is that ICT has complemented non-routine analytic tasks but substituted for routine tasks whilst not affecting non-routine manual tasks (like cleaning, gardening, childcare, etc.). This implies that many middle-skilled groups like bank clerks and paralegals performing routine tasks have suffered a fall in demand. To test this we have estimated industry-level skill share equations distinguishing three education groups and related this to ICT (and R&D) investments in eleven countries over 25 years using newly available data. Our findings are supportive of the ICT-based polarization hypothesis as industries that experienced the fastest growth in ICT also experienced the fastest growth in the demand for the most educated workers and the fastest falls in demand for workers with intermediate levels of education. The magnitudes are nontrivial: technical change can account for up to a

relied on.

quarter of the growth of the college wage bill share in the economy as a whole (and more in the tradable sectors).

Although our method is simple and transparent, there are many extensions that need to be made. First, alternative instrumental variables for ICT would help identify the causal impact of ICT. Second, although we find no direct role for trade variables, there may be other ways in which globalization influences the labour market, for example by causing firms to "defensively innovate" (Acemoglu (2003)). Third, there are alternative explanations for the improved performance of the least skilled group through for example, greater demand from richer skilled workers for the services they provide as market production substitutes for household production (e.g. childcare, eating out in restaurants, domestic work, etc.)[23]. These explanations may complement the mechanism that we address here. Finally, we have not used richer occupational data that would focus on the skill content of tasks due to the need to have international comparability across countries. The work of Autor and Dorn (2009) is an important contribution here.

[23] Ngai and Pissarides (2007), Mazzolari and Ragusa (2008)

Appendix A

Figures: Chapter 1

Figure A.1 Allocation of SC seats to a district

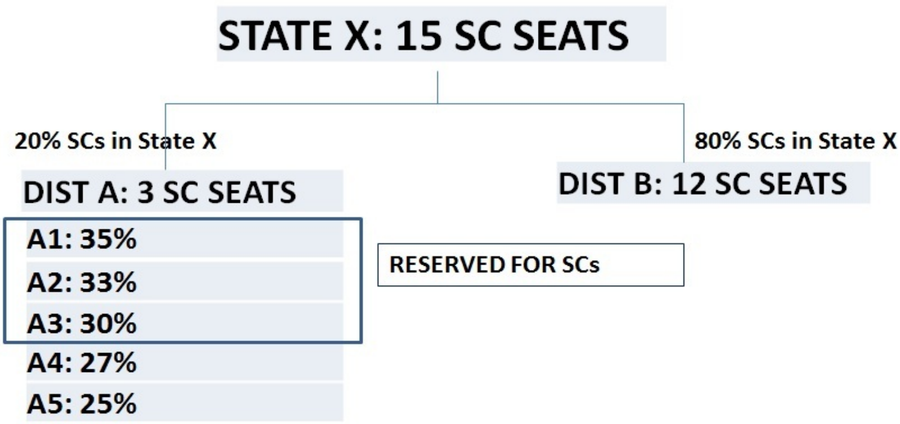


Figure A.2 Identification of District Cutoff

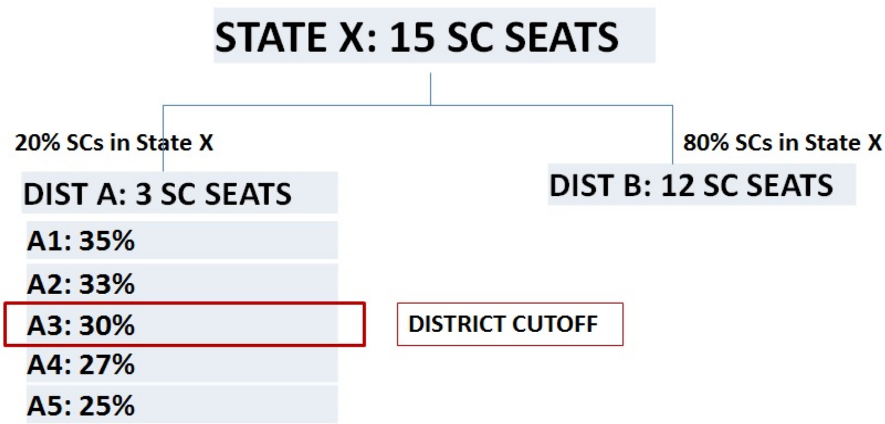


Figure A.3 Identification of constituencies close to the threshold

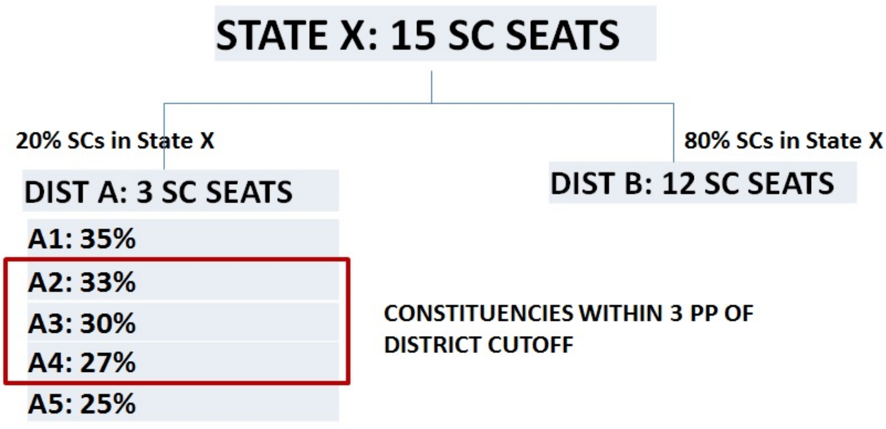


Figure A.4 Discarding previously-reserved constituencies

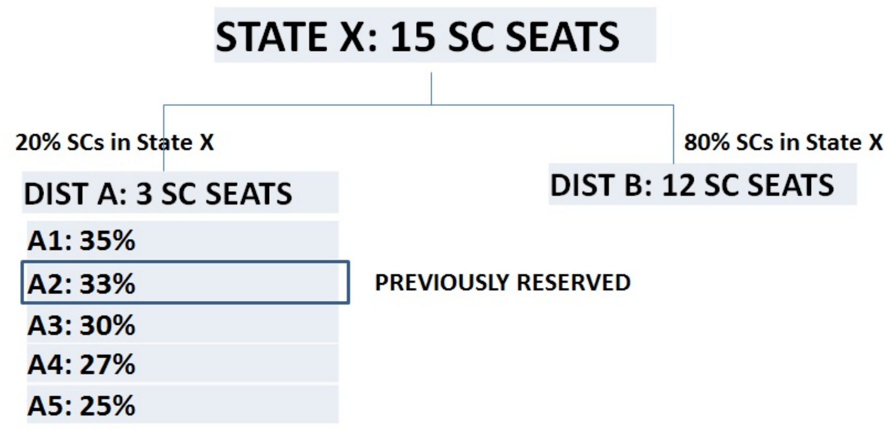
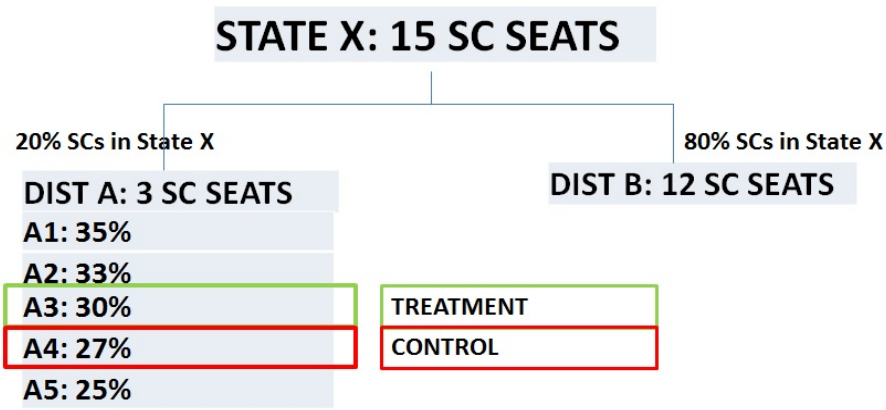


Figure A.5 Identification of Treatment and Control Groups



Appendix B

Tables: Chapter 1

Table B.1: Constituency Averages: Chhatisgarh, Karnataka, Madhya Pradesh and Rajasthan 2001

	Treated	Untreated	Difference
Observations	38	69	
Total Population	32729	45679	-12950
	(12417)	(10558)	(16276)
Fraction of Scheduled Castes (SC)	0.21	0.20	0.01
	(0.01)	(0.01)	(0.01)
Fraction of Scheduled Tribes (ST)	0.11	0.09	0.02
	(0.02)	(0.01)	(0.02)
Fraction of Females	0.48	0.48	-0.001
	(0.002)	(0.001)	(0.003)
Fraction of Illiterates	0.53	0.53	-0.003
	(0.01)	(0.01)	(0.02)
Employed as a Fraction of Total Population	0.47	0.48	-0.01
	(0.01)	(0.01)	(0.01)

Notes: top row: Averages at constituency level. Standard error clustered at constituency level in parentheses. All data taken from the 2001 Census data for Chhatisgarh, Madhya Pradesh, Karnataka and Rajasthan.

Table B.2: Constituency Electoral Characteristics

	Treated	Untreated	Difference
Observations	38	69	
Panel A: Constituency Electoral Characteristics at Baseline: 2003 and 2004			
Electors	168060	165826	2234
	(3475)	(2740)	(4419)
Female candidates	0.05	0.06	-0.01
	(0.01)	(0.01)	(0.02)
Candidates from Right-wing Parties	0.11	0.14	-0.03
	(0.01)	(0.01)	(0.01)
Candidates from Left/Centre-Left Parties	0.16	0.19	-0.03
	(0.01)	(0.01)	(0.01)
Candidates from Lower-Caste Parties	0.14	0.10	0.03
	(0.01)	(0.01)	(0.02)
Female candidates winning	0.03	0.03	0.00
	(0.03)	(0.02)	(0.03)
Candidates from Right-wing Parties winning	0.53	0.57	-0.04
	(0.08)	(0.06)	(0.10)
Candidates from Left/Centre-Left Parties winning	0.18	0.33	-0.15
	(0.06)	(0.06)	(0.09)
Candidates from Lower-Caste Parties winning	0.03	0.01	0.01
	(0.03)	(0.01)	(0.03)
Panel B: Constituency Electoral Characteristics in 2008			
Electors	170311	172300	-1990
	(3682)	(2510)	(4447)
Female candidates	0.08	0.06	0.02
	(0.02)	(0.01)	(0.02)
Candidates from Right-wing Parties	0.09	0.11	-0.01
	(0.01)	(0.004)	(0.01)
Candidates from Left/Centre-Left Parties	0.11	0.14	-0.02
	(0.01)	(0.01)	(0.01)
Candidates from Lower-Caste Parties	0.13	0.13	-0.003
	(0.01)	(0.01)	(0.01)
Female candidates winning	0.18	0.14	0.04
	(0.06)	(0.04)	(0.08)
Candidates from Right-wing Parties winning	0.63	0.41	0.23
	(0.08)	(0.06)	(0.10)
Candidates from Left/Centre-Left Parties winning	0.26	0.46	-0.20
	(0.07)	(0.06)	(0.09)
Candidates from Lower-Caste Parties winning	0.03	0.01	0.01
	(0.03)	(0.01)	(0.03)

Notes: Standard error of mean in parentheses. All data taken from the 2003 and 2004 Election Commission of India State Legislative Assembly Results for Chhatisgarh, Madhya Pradesh, Rajasthan and Karnataka."Left" parties are: the Communist Party of India (and offshoots) and the Indian National Congress; "Right" parties: the Bharatiya Janata Party (BJP); "Lower-caste" parties: the Bahujan Samaj Party (BSP).

Table B.3: Averages of Dependent Variables

	Pre	Post	Difference
Turnout			
Treated	0.69	0.63	-0.05
	(0.01)	(0.01)	(0.01)
Untreated	0.70	0.70	0.00
	(0.01	(0.01)	(0.00)
Difference	-0.01	-0.07	-0.06
	(0.01)	(0.01)	(0.01)
Log (Candidates/Electors)			
Treated	3.94	4.23	0.30
	(0.06)	(0.07)	(0.07)
Untreated	3.86	4.07	0.22
	(0.05)	(0.05)	(0.05)
Difference	0.08	0.16	0.08
	(0.07)	(0.09)	(0.08)
Margin of Victory			
Treated	0.11	0.11	0.00
	(0.01)	(0.01)	(0.02)
Untreated	0.12	0.09	-0.03
	(0.01)	(0.01)	(0.01)
Difference	0.00	0.02	0.03
	(0.02)	(0.02)	(0.02)
Right-wing candidates winning			
Treated	0.53	0.63	0.11
	(0.08)	(0.08)	(0.11)
Untreated	0.57	0.41	-0.16
	(0.06)	(0.06)	(0.08)
Difference	-0.04	0.23	0.26
	(0.10)	(0.10)	(0.13)
Centre/Centre-Left candidates winning			
Treated	0.18	0.26	0.08
	(0.06)	(0.07)	(0.10)
Untreated	0.33	0.46	0.13
	(0.06)	(0.06)	(0.08)
Difference	-0.15	-0.20	-0.05
	(0.09)	(0.09)	(0.13)
Lower-Caste party candidates winning			
Treated	0.03	0.03	0.00
	(0.03)	(0.03)	(0.04)
Untreated	0.01	0.01	0.00
	(0.01)	(0.01)	(0.02)
Difference	0.01	0.01	0.00
	(0.03)	(0.03)	(0.04)

Notes: Number of Treated Constituencies: 38. Number of Untreated Constituencies: 69. Standard error of mean in parentheses. All data taken from the 2003, 2004 and 2008 Election Commission of India State Legislative Assembly Results for Chhatisgarh, Madhya Pradesh, Rajasthan and Karnataka."Right" parties: the Bharatiya Janata Party (BJP). Candidates/Electors multiplied everywhere by 1000000.

Table B.4: Effect of reservation for Scheduled Castes (SCs) in 2008 (Elections from 2001-2008)

	(1)	(2)	(3)	(4)
		Panel A: Turnout		
Reserved Constituency		-0.04***	-0.01	0.001
		(0.01)	(0.01)	(0.01)
Post Reservation		-0.02***	0.00	0.004
		(0.01)	(0.01)	(0.01)
Reserved Constituency Post Reservation			-0.06***	-0.06***
			(0.01)	(0.01)
Constant	0.68***	0.71***	0.70***	
	(0.00)	(0.01)	(0.01)	
District FE				Y
Observations	214	214	214	214
R-squared	0.00	0.09	0.13	0.73
		Panel B: Log (Candidates/Electors)		
Reserved Constituency		0.12*	0.08	0.03
		(0.07)	(0.08)	(0.08)
Post Reservation		0.24***	0.22***	0.22***
		(0.04)	(0.05)	(0.06)
Reserved Constituency Post Reservation			0.08	0.08
			(0.08)	(0.10)
Constant	-9.81***	-9.97***	-9.96***	
	(0.01)	(0.05)	(0.05)	
District FE				Y
Observations	214	214	214	214
R-squared	0.00	0.10	0.10	0.56
		Panel C: Margin of Victory		
Reserved Constituency		0.01	-0.005	-0.02
		(0.01)	(0.02)	(0.02)
Post Reservation		-0.02	-0.03*	-0.03*
		(0.01)	(0.01)	(0.02)
Reserved Constituency Post Reservation			0.03	0.03
			(0.02)	(0.03)
Constant	0.10***	0.11***	0.12***	
	(0.00)	(0.01)	(0.01)	
District FE				Y
Observations	214	214	214	214
R-squared	0.00	0.01	0.02	0.36

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

Notes: Standard errors in parentheses. I define constituencies as eligible for reservation if they have a fraction of SCs no higher than 3 percentage points more than the minimum fraction of SCs in SC-reserved constituencies within a district. Candidates/Electors multiplied everywhere by 1000000.

Table B.5: Effect of reservation for Scheduled Castes (SCs) in 2008 (Elections from 2001-2008) on Incidence of Victory of Party Categories

	(1)	(2)	(3)	(4)
	Panel A: Right-Wing			
Reserved Constituency		-0.04	0.08	-0.10
		(0.10)	(0.11)	(0.26)
Post Reservation		-0.16*	-0.16*	-0.40*
		(0.08)	(0.10)	(0.21)
Reserved Constituency Post Reservation		0.26**	0.26*	0.67**
		(0.13)	(0.15)	(0.34)
Constant	0.52***	0.57***		0.16
	(0.04)	(0.06)		(0.15)
Specification	OLS	OLS	OLS	PROBIT
District FE			Y	
Observations	214	214	214	99
R-squared	0.00	0.03	0.34	0.02
	Panel B: Centre/Centre-Left			
Reserved Constituency		-0.15*	-0.21**	-0.47*
		(0.09)	(0.10)	(0.28)
Post Reservation		0.13	0.13	0.34
		(0.08)	(0.09)	(0.21)
Reserved Constituency Post Reservation		-0.05	-0.05	-0.07
		(0.13)	(0.15)	(0.40)
Constant	0.34***	0.33***		-0.51***
	(0.03)	(0.06)		(0.16)
Specification	OLS	OLS	OLS	PROBIT
District FE			Y	
Observations	214	214	214	99
R-squared	0.00	0.05	0.33	0.043
	Panel C: Lower-Caste Parties			
Reserved Constituency		0.01	-0.02	0.25
		(0.03)	(0.03)	(0.58)
Post Reservation		-0.00	0.00	-0.00
		(0.02)	(0.02)	(0.56)
Reserved Constituency Post Reservation		0.00	-0.00	0.00
		(0.04)	(0.05)	(0.83)
Constant	0.02**	0.01		-2.18***
	(0.01)	(0.01)		(0.39)
Specification	OLS	OLS	OLS	PROBIT
District FE			Y	
Observations	214	214	214	99
R-squared	0.00	0.06	0.37	0.01

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

Notes: Standard errors in parentheses. I define constituencies as eligible for reservation if they have a fraction of SCs no higher than 3 percentage points more than the minimum fraction of SCs in SC-reserved constituencies within a district.

Table B.6: Effect of dereservation for Scheduled Castes (SCs) in 2008 (Elections from 2001-2008)

	(1)	(2)	(3)	(4)	(5)	(6)
	Turnout		Log(Candidates /Electors)		Margin of Victory	
Reserved Constituency	0.00		0.03		-0.02	
	(0.01)		(0.08)		(0.02)	
Post Reservation	0.00	0.01	0.22***	0.18	-0.03*	-0.06
	(0.01)	(0.01)	(0.06)	(0.12)	(0.02)	(0.04)
Reserved Constituency Post Reservation	-0.06***		0.08		0.02	
	(0.01)		(0.10)		(0.03)	
Dereserved Constituency		0.06***		-0.02		-0.02
		(0.02)		(0.21)		(0.03)
Dereserved Constituency Post Dereservation		0.04**		0.43**		0.03
		(0.02)		(0.18)		(0.05)
Observations	214	99	214	99	214	99
R-squared	0.73	0.87	0.56	0.68	0.3	0.38
	Right-Wing Parties		Centre/Centre-Left Parties		Lower-Caste Parties	
Reserved Constituency	0.08		-0.21		-0.02	
	(0.11)		(0.10)		(0.03)	
Post Reservation	-0.16*	-0.24	0.13	0.29	0.00	0.00
	(0.1)	(0.20)	(0.09)	(0.20)	(0.02)	(0.00)
Reserved Constituency Post Reservation	0.26*		-0.05		-0.00	
	(0.16)		(0.15)		(0.05)	
Dereserved Constituency		-0.07		0.04		-0.04
		(0.22)		(0.22)		(0.03)
Dereserved Constituency Post Dereservation		0.09		-0.22		0.07
		(0.27)		(0.27)		(0.07)
Observations	214	99	214	99	214	99
R-squared	0.35	0.44	0.33	0.39	0.36	0.53

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

Notes: Standard errors in parentheses. I define constituencies as eligible for reservation if they have a fraction of SCs no higher than 3 percentage points more than the minimum fraction of SCs in SC-reserved constituencies within a district. All regressions have district and year fixed effects. Standard errors are clustered by constituency. Candidates/Electors multiplied everywhere by 1000000.

Table B.7: Effect of reservation for Scheduled Castes (SCs) in 2008 (Elections from 1993-1999)

	(1)	(2)	(3)
Panel A: Turnout			
Reserved Constituency	0.00	-0.00	-0.00
	(0.01)	(0.01)	(0.01)
Post Reservation	0.00	0.00	0.01***
	(0.01)	(0.01)	(0.01)
Reserved Constituency Post Reservation	-0.06***	-0.06***	-0.00
	(0.01)	(0.01)	(0.01)
Period: 2003-2008	Y	Y	
Sample: Constituencies with Available Data for 1993-1999		Y	Y
Period: 1993-199			Y
Observations	214	204	204
R-squared	0.73	0.72	0.75
Panel B: Log (Number of Candidates/Electors)			
Reserved Constituency	0.03	0.04	-0.07
	(0.08)	(0.08)	(0.08)
Post Reservation	0.22***	0.22***	-0.73***
	(0.05)	(0.06)	(0.05)
Reserved Constituency Post Reservation	0.08	0.10	0.17
	(0.10)	(0.09)	(0.12)
Period: 2003-2008	Y	Y	
Sample: Constituencies with Available Data for 1993-1999		Y	Y
Period: 1993-199			Y
Observations	214	204	204
R-squared	0.56	0.56	0.69
Panel C: Margin of Victory			
Reserved Constituency	-0.02	-0.02	-0.02
	(0.02)	(0.02)	(0.03)
Post Reservation	-0.03*	-0.03*	0.01
	(0.02)	(0.02)	(0.02)
Reserved Constituency Post Reservation	0.03	0.03	0.00
	(0.03)	(0.03)	(0.04)
Period: 2003-2008	Y	Y	
Sample: Constituencies with available data for 1993-1999		Y	Y
Period: 1993-1999			Y
Observations	214	204	204
R-squared	0.36	0.37	0.33

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

Notes: Standard errors in parentheses. I define constituencies as eligible for reservation if they have a fraction of SCs no higher than 3 percentage points more than the minimum fraction of SCs in SC-reserved constituencies within a district. All regressions have district fixed effects. Candidates/Electors multiplied everywhere by 1000000.

Table B.8: Effect of reservation for Scheduled Castes (SCs) in 2008 on success of political parties (Elections from 1993-1999)

	(1)	(2)	(3)
Panel A: Right-wing Parties			
Reserved Constituency	0.08	0.07	-0.12
	(0.11)	(0.12)	(0.09)
Post Reservation	-0.16*	-0.17*	-0.12
	(0.09)	(0.10)	(0.08)
Reserved Constituency Post Reservation	0.26*	0.31*	0.15
	(0.15)	(0.16)	(0.14)
Period: 2003-2008	Y	Y	
Sample: Constituencies with Available Data for 1993-1999		Y	Y
Period: 1993-199			Y
Observations	214	204	204
R-squared	0.34	0.34	0.40
Panel B: Left/Centre-Left Parties			
Reserved Constituency	-0.21**	-0.22**	0.00
	(0.10)	(0.10)	(0.10)
Post Reservation	0.13	0.14	0.21**
	(0.09)	(0.09)	(0.09)
Reserved Constituency Post Reservation	-0.05	-0.05	0.01
	(0.15)	(0.15)	(0.16)
Period: 2003-2008	Y	Y	
Sample: Constituencies with Available Data for 1993-1999		Y	Y
Period: 1993-199			Y
Observations	214	204	204
R-squared	0.33	0.33	0.40
Panel C: Lower-Caste Parties			
Reserved Constituency	-0.02	-0.01	0.00
	(0.03)	(0.02)	(0.02)
Post Reservation	0.00	0.00	0.00
	(0.02)	(0.02)	(0.00)
Reserved Constituency Post Reservation	-0.00	0.03	-0.00
	(0.05)	(0.04)	(0.05)
Period: 2003-2008	Y	Y	
Sample: Constituencies with available data for 1993-1999		Y	Y
Period: 1993-1999			Y
Observations	214	204	204
R-squared	0.36	0.33	0.50

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

Notes: Standard errors in parentheses. I define constituencies as eligible for reservation if they have a fraction of SCs no higher than 3 percentage points more than the minimum fraction of SCs in SC-reserved constituencies within a district. All regressions have district fixed effects. Candidates/Electors multiplied everywhere by 1000000.

Table B.9: Effect of reservation for Scheduled Castes (SCs) in 2008 (Elections from 2001-2008): 5% cutoff

VARIABLES	(1) Turnout	(2) Log (Candidates/Electors)	(3) Margin of Victory
Reserved Constituency	-0.01	0.04	0.01
	(0.01)	(0.06)	(0.01)
Post Reservation	0.01**	0.26***	-0.01
	(0.003)	(0.03)	(0.01)
Reserved Constituency Post Reservation	-0.06***	0.04	0.003
	(0.01)	(0.08)	(0.02)
Constant	0.70***	3.90***	0.10***
	(0.005)	(0.03)	(0.01)
Observations	357	357	357
R-squared	0.09	0.1	0.01

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

Notes: Standard errors in parentheses. I define constituencies as eligible for reservation if they have a fraction of SCs no higher than 5 percentage points more than the minimum fraction of SCs in SC-reserved constituencies within a district. All regressions have district fixed effects. Candidates/Electors multiplied everywhere by 1000000.

Table B.10: Effect of reservation for Scheduled Castes (SCs) in 2008 (Elections from 2001-2008): districts with both treated and untreated constituencies

	(1)	(2)	(3)
VARIABLES	Turnout	Log (Candidates/Electors)	Margin of Victory
Reserved Constituency	-0.002	0.03	-0.003
	(0.02)	(0.09)	(0.02)
Post Reservation	-0.004	0.18***	-0.01
	(0.01)	(0.05)	(0.02)
Reserved Constituency Post Reservation	-0.05***	0.15	0.01
	(0.01)	(0.11)	(0.03)
Constant	0.69***	3.90***	0.10***
	(0.01)	(0.06)	(0.02)
Observations	120	120	120
R-squared	0.09	0.10	0.002

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

Notes: Standard errors in parentheses. I define constituencies as eligible for reservation if they have a fraction of SCs no higher than 3 percentage points more than the minimum fraction of SCs in SC-reserved constituencies within a district. I restrict the sample to districts which have both treated and untreated constituencies. Candidates/Electors multiplied everywhere by 1000000.

Table B.11: Respondent Characteristics: Lokniti Constituencies, Karnataka Post-Poll

	Treated	Untreated	Difference
Number of respondents	405	497	
Fraction of SC respondents	0.16	0.15	0.01
	(0.04)	(0.03)	(0.05)
Fraction of ST respondents	0.02	0.03	-0.01
	(0.01)	(0.01)	(0.02)
Fraction of Minority respondents	0.29	0.33	-0.04
	(0.06)	(0.04)	(0.07)
Fraction of Upper-caste Hindu respondents	0.71	0.67	0.04
	(0.06)	(0.04)	(0.07)
Fraction of Female respondents	0.49	0.42	0.06
	(0.03)	(0.02)	(0.03)
Fraction of Illiterate respondents	0.25	0.32	-0.07
	(0.06)	(0.05)	(0.08)
Number of Cows/buffaloes	2.06	1.92	0.14
	(0.28)	(0.36)	(0.44)
Monthly Household Income (INR)	2329.02	2920.52	-591.50
	(221.99)	(665.46)	(682.84)
Age of respondent	41.63	42.23	-0.59
	(0.78)	(1.04)	(1.25)
Number of children in household	2.42	2.36	0.06
	(0.22)	(0.17)	(0.26)
Right supporters	0.31	0.26	0.05
	(0.07)	(0.07)	(0.09)
Voted in 2004	0.94	0.87	0.07
	(0.01)	(0.03)	(0.03)
Uninformed voters	.16	0.20	-0.04
	(.06)	(0.05)	(0.07)

Standard errors in parentheses. All data taken from the Lokniti 2008 Post-Poll Survey in Karnataka. Constituencies were chosen among those which were close to the district cutoff for reservation. These are: Hungund, Aurad, Kanakagiri, Koppal, Ron, Hanagal, Hadagalli, Sira, Gowribidanur, Sidlaghatta,Mulbagal,Hosakote,Kanakapura,Sakleshpur and Nanjangud."Uninformed" refers to respondents who said that they never read newspapers, watched news on TV or listened to news on radio

Table B.12: Constituency Averages at Baseline: Karnataka 2001

	Treated	Untreated	Difference
Observations	1420	1827	
Total Population	1128.08	1419.452	-291.37
	(339.11)	(178.01)	(364.55)
Fraction of Scheduled Castes (SC)	0.25	0.21	0.03
	(0.02)	(0.01)	(0.02)
Fraction of Scheduled Tribes (ST)	0.06	0.08	-0.02
	(0.03)	(0.01)	(0.03)
Fraction of Females	0.50	0.49	0.01
	(0.00)	(0.00)	(0.00)
Fraction of Illiterates	0.48	0.48	0.00
	(0.04)	(0.02)	(0.04)
Employed as a Fraction of Total Population	0.50	0.51	-0.01
	(0.02)	(0.02)	(0.03)
Employed Males as a Fraction of Total Males	0.59	0.59	-0.01
	(0.02)	(0.01)	(0.02)

Notes: Top row: Characteristics averaged across villages/towns/sub-districts. Standard errors in parentheses. All data taken from the 2001 Census data for Karnataka.Constituencies were chosen among those which were close to the district cutoff for reservation. These are: Hungund, Aurad, Kanakagiri, Koppal, Ron, Hanagal, Hadagalli, Sira, Gowribidanur, Sidlaghatta,Mulbagal,Hosakote,Kanakapura,Sakleshpur and Nanjangud.

Table B.13: Candidate Characteristics (Lokniti constituencies)

	Treated	Untreated	Difference
	Baseline: Karnataka 2004		
Observations	52	59	
Scheduled Caste (SC) candidates	0.13	0.05	0.08
	(0.02)	(0.03)	(0.03)
Scheduled Tribe (ST) candidates	0.06	0.00	0.07
	(0.04)	(0.00)	(0.04)
Female candidates	0.04	0.07	-0.03
	(0.03)	(0.03)	(0.04)
Candidates from Centre/Centre-Left Parties	0.13	0.15	-0.02
	(0.02)	(0.01)	(0.02)
Candidates from Right Parties	0.10	0.14	-0.04
	(0.02)	(0.02)	(0.02)
Candidates from Lower-Caste Parties	0.08	0.05	0.03
	(0.02)	(0.03)	(0.03)
	After Treatment: Karnataka 2008		
Observations	81	90	
Female candidates	0.01	0.03	-0.02
	(0.03)	(0.02)	(0.02)
Candidates from Centre/Centre-Left Parties	0.12	0.15	-0.03
	(0.02)	(0.01)	(0.02)
Candidates from Right Parties	0.10	0.13	-0.04
	(0.02)	(0.02)	(0.03)
Candidates from Lower-Caste Parties	0.07	0.02	0.05
	(0.03)	(0.02)	(0.03)

Notes: Standard error of mean in parentheses. All data taken from the 2004 and 2008 Election Commission of India State Legislative Assembly Results for Karnataka. Constituencies were chosen among those which were close to the district cutoff for reservation. These are: Hungund, Aurad, Kanakagiri, Koppal, Ron, Hanagal, Hadagalli, Sira, Gowribidanur, Sidlaghatta,Hosakote,Sakleshpur, Mulbagal, Kanakapura and Nanjangud."Left" parties are: the Communist Party of India (and offshoots) and the Indian national Congress; "Right" parties: the Bharatiya Janata Party (BJP); "Lower-caste" parties: the Bahujan Samaj Party (BSP).

Table B.14: Individual Voter Participation: Lokniti Karnataka 2008 Post-Poll

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
RE*POST		-0.04	-0.04	0.02	0.15	-0.01	-0.09	-0.01	-0.09	0.05	0.41	0.05	0.41	-0.03	-0.19	-0.04	-0.31
		(0.05)	(0.05)	(0.06)	(0.34)	(0.06)	(0.41)	(0.06)	(0.41)	(0.07)	(0.41)	(0.07)	(0.40)	(0.08)	(0.45)	(0.06)	(0.40)
Female				-0.05*	-0.27**					-0.6	-0.30**	-0.05*	-0.28**				
				(0.03)	(0.12)					(0.03)	(0.14)	(0.03)	(0.13)				
Female*RE*POST				-0.15**	-1.08***					-0.15**	-1.11***	-0.15**	-1.12***				
				(0.06)	(0.40)					(0.06)	(0.42)	(0.06)	(0.40)				
SC						-0.03	-0.18			-0.02	-0.16						
						(0.04)	(0.24)			(0.05)	(0.24)						
SC*RE*POST						-0.08	-0.70			-0.07	-0.68						
						(0.08)	(0.48)			(0.08)	(0.47)						
ST/Other Minority						-0.08	-0.38*			-0.08	-0.42**						
						(0.05)	(0.20)			(0.05)	(0.21)						
ST/Other Minority*RE*POST						-0.11*	-0.71**			-0.13*	-0.85**						
						(0.06)	(0.36)			(0.07)	(0.39)						
Any Minority								-0.05	-0.29**			-0.05	-0.30**				
								(0.03)	(0.14)			(0.03)	(0.14)				
Any Minority*RE*POST								-0.09*	-0.65**			-0.10*	-0.71**				
								(0.05)	(0.29)			(0.05)	(0.28)				
Illiterate														0.002	0.04		
														(0.06)	(0.27)		
Illiterate*RE*POST														-0.05	-0.42		
														(0.10)	(0.48)		
Uninformed																0.02	0.08
																(0.04)	(0.28)
Uninformed*RE*POST																0.01	-0.01
																(0.08)	(0.65)
Constant	0.91***	0.87***	0.92***														
	(0.02)	(0.03)	(0.02)														
Observations	1804	1804	1804	1804	1804	1804	1804	1804	1804	1804	1804	1804	1804	1804	1804	1804	1804
Constituency FE			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Specification	LPM	LPM	LPM	LPM	PRO	LPM	PRO	LPM	PRO	LPM	PRO	LPM	PRO	LPM	PRO	LPM	PRO

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

Notes: Standard errors in parentheses. All data taken from the Lokniti 2008 Post-Poll Survey in Karnataka. Constituencies were chosen among those which were close to the district cutoff for reservation. These are: Hungund, Aurad, Kanakagiri, Koppal, Ron, Hanagal, Hadagalli, Sira, Gowribidanur, Sidlaghatta,Mulbagal,Hosakote,Kanakapura,Sakleshpur and Nanjangud.

Appendix C

Data Appendix: Chapter 1

I use three chief sources to arrive at descriptive statistics or controls in the main regressions: the Primary Census Abstracts from the 2001 Census of India; constituency-level electoral data for the State Legislative Assembly Elections from the Election Commission of India (Chhatisgarh, Madhya Pradesh and Rajasthan: 2003 and 2008; Karnataka:2004 and 2008) and individual voting data from the 2008 Karnataka Post-Poll Survey, released by Lokniti and the Centre for the Study of Developing Societies.

To arrive at constituency controls, I match each village or town in a district to a constituency (Concordance available on request). The 2008 round of delimitation stated explicitly that every constituency would be wholly contained in one district. The Delimitation guidelines set out the extent of each constituency. I match every unit (village, town, ward or other administrative unit) to its corresponding constituency, and then assign it to its "2008" district. This might be of some concern if new districts are created by merging parts of others together, or other substantial redrawing of boundaries. For the most part, however (and certainly within my sample), new districts are created by splitting an existing district into two or three, so each district in 2008 has exactly one analogue in previous years. I am taking the extent of each constituency as laid out in the 2008 Delimitation document. I do not find evidence of any other substantial redefinition of constituency limits. I assume that gerrymandering, where it exists, is either limited or not biased towards either reserved or unreserved constituencies. This is borne out by the survey carried out by Iyer and Shivakumar (2009), who find that Delimitation arranged constituencies to even out the population of each constituency, without visible party or political bias.

In the individual-level voting data from Lokniti, I remove missing observations: those who were too young to vote in 2004 or 2008, or do not remember whether they voted in either year.

Appendix D

Proofs of Propositions: Chapter 2

D.1 Proof of Proposition 1

Proof of Proposition 1. I consider in turn an interior $\bar{h}$ and then $\bar{h} = c^{-1}(1)$ and $\bar{h} = 0$.

- Consider first $h(\bar{I}^0) = 0$.

$$\begin{aligned} u(f(h)(1-c(h'))) - (1-\pi)u(f(h)) &= -\pi I \\ \implies \pi u(f(h)) &= -\pi I \\ \implies h &= 0 \& I = 0 \& \pi = 0 \\ \implies \bar{h} &> 0 \forall h > 0, \forall I^1 > I^0 \\ \implies \bar{h} &\geq 0, h = 0 \end{aligned}$$

- Next, consider $h(\bar{I}^0) = c^{-1}(1)$

$$\begin{aligned} u(f(h)(1-c(\bar{h}))) - (1-\pi)u(f(h)) &\geq -\pi I \\ \implies -(1-\pi)u(f(h)) &\geq -\pi I \\ \implies h(\bar{I}^1) &\geq c^{-1}(1) \forall I^1 > I^0 \end{aligned}$$

- Finally consider an interior $\bar{h}$ i.e. $0 < \bar{h} < c^{-1}(1)$. If $\bar{h} = c^{-1}[1 - 1/f(h) \cdot$

$u^{-1}((1-\pi)\cdot u(f(h))-\pi\cdot I)]$:

$$\begin{aligned}\frac{\partial\bar{h}}{\partial I} &= (c^{-1})'[1-\frac{1}{f(h)}\cdot u^{-1}((1-\pi)\cdot u(f(h))-\pi\cdot I)] \\ &\cdot[-\frac{1}{f(h)}\cdot(u^{-1})'((1-\pi)\cdot u(f(h))-\pi\cdot I)]\cdot(-\pi)>0\end{aligned}$$

- To prove concavity of interior $\bar{h}$: if $(c^{-1})'(.)>0,(c^{-1})''(.)<0,(u^{-1})'(.)>0,(u^{-1})''(.)>0$

$$\begin{aligned}\frac{\partial^2\bar{h}}{\partial I^2} &= (c^{-1})''[1-\frac{1}{f(h)}\cdot(u^{-1})'((1-\pi)\cdot u(f(h))-\pi\cdot I)] \\ &\cdot[(u^{-1})'((1-\pi)\cdot u(f(h))-\pi\cdot I)]^2\cdot\frac{\pi^2}{(f(h))^2} \\ &+(c^{-1})'[1-\frac{1}{f(h)}\cdot u^{-1}((1-\pi)\cdot u(f(h))-\pi\cdot I)] \\ &\cdot(u^{-1})''((1-\pi)\cdot u(f(h))-\pi\cdot I)]\cdot\frac{-\pi^2}{f(h)}\leq 0\end{aligned}$$

- If $h(\bar{I}^0)=0, h(\bar{I}^1)\in\{0,c^{-1}[1-\frac{1}{f(h)}\cdot u^{-1}((1-\pi)\cdot u(f(h))-\pi\cdot I)],c^{-1}(1)\}$

□

D.2 Proof of Proposition 2

Proof of Proposition 2. I consider in turn an interior $\bar{h}$ and then $\bar{h}=c^{-1}(1)$ and $\bar{h}=0$.

- Consider first $h(\bar{\pi}^0)=0$.

$$\begin{aligned}u(f(h)(1-c(h')))-(1-\pi)u(f(h)) &= -\pi I \\ \implies \pi u(f(h)) &= -\pi I \\ \implies h &= 0\&I=0\vee\pi=0 \\ \implies \bar{h} &= 0,\pi=0 \\ \implies \bar{h} &> 0\forall\pi^1>\pi^0\end{aligned}$$

- Next, consider $h(\bar{\pi}^0) = c^{-1}(1)$

$$\begin{aligned} u(f(h)(1-c(\bar{h}))) - (1-\pi)u(f(h)) &\geq -\pi I \\ \implies -(1-\pi)u(f(h)) &\geq -\pi I \\ \implies h(\bar{\pi}^1) &\geq c^{-1}(1) \forall \pi^1 > \pi^0 \end{aligned}$$

- Finally consider an interior $\bar{h}$ i.e. $0 < \bar{h} < c^{-1}(1)$. If $\bar{h} = c^{-1}[1 - 1/f(h) \cdot u^{-1}((1-\pi) \cdot u(f(h)) - \pi \cdot I)]$:

$$\begin{aligned} \frac{\partial \bar{h}}{\partial \pi} &= (c^{-1})'[1 - \frac{1}{f(h)} \cdot u^{-1}((1-\pi) \cdot u(f(h)) - \pi \cdot I)] \\ &\cdot [-\frac{1}{f(h)} \cdot (u^{-1})'((1-\pi) \cdot u(f(h)) - \pi \cdot I)] \cdot (-u(f(h)) - I) > 0 \end{aligned}$$

- To prove concavity of interior $\bar{h}$: if $(c^{-1})'(.) > 0, (c^{-1})''(.) < 0, (u^{-1})'(.) > 0, (u^{-1})''(.) > 0$

$$\begin{aligned} \frac{\partial^2 \bar{h}}{\partial \pi^2} &= (c^{-1})''[1 - \frac{1}{f(h)} \cdot (u^{-1})'((1-\pi) \cdot u(f(h)) - \pi \cdot I)] \\ &\cdot [(u^{-1})'((1-\pi) \cdot u(f(h)) - \pi \cdot I)]^2 \cdot \frac{(u(f(h)) + I)^2}{(f(h))^2} \\ &+ (c^{-1})'[1 - \frac{1}{f(h)} \cdot u^{-1}((1-\pi) \cdot u(f(h)) - \pi \cdot I)] \\ &\cdot (u^{-1})''((1-\pi) \cdot u(f(h)) - \pi \cdot I)] \cdot \frac{-(u(f(h)) + I)^2}{f(h)} \leq 0 \end{aligned}$$

- If $h(\bar{I}^0) = 0, h(\bar{I}^1) \in \{0, c^{-1}[1 - \frac{1}{f(h)} \cdot u^{-1}((1-\pi) \cdot u(f(h)) - \pi \cdot I)], c^{-1}(1)\}$

□

D.3 Proof of Proposition 3

Proof of Proposition 3. I consider in turn $\bar{h} = 0$, $\bar{h} = c^{-1}(1)$ and interior $\bar{h}$.

- Consider first $c(\bar{h}) = 1$, $h^1 > h^0 > 0$, $I > 0$. Keeping I constant, if surplus over autarky at $h^0, c(h'(h^0))$ is the same as that at $h^1, c(h'(h^1))$:

$$\begin{aligned} u(f(h^1)(1-c(h'(h^1)))) - (1-\pi)\cdot u(f(h^1)) &= -\pi \cdot I \\ &= u(f(h^0)(1-c(h'(h^0)))) \\ &\quad -(1-\pi)\cdot u(f(h^0)) \\ &= -(1-\pi)\cdot u(f(h^0)) \end{aligned}$$

$$\begin{aligned} c(\bar{h}) = 1 &\implies u(f(h^1)(1-c(h'(h^1)))) > 0 \\ &\implies c(h'(h^1)) < c(h'(h^0)) \\ &\implies h'(h^1) < h'(h^0) \end{aligned}$$

- Consider next I=0. Then:

$$u(f(h)(1-c(h'))) - (1-\pi)u(f(h)) = -\pi \cdot I \implies h = 0 \vee h' = 0$$

- Consider finally $h^1 > h^0 > 0$. $0 < h^1 < c^{-1}(1)$. Keeping I constant, if surplus over autarky at $h^0, c(h'(h^0))$ is the same as that at $h^1, c(h'(h^1)).f'(h) > 0, f''(h) \leq 0, c'(h) > 0, c''(h) > 0$, therefore:

$$\begin{aligned} \bar{h}(h^1) \geq \bar{h}(h^0) \implies & u(f(h^1)(1-c(\bar{h}(h^1)))) - (1-\pi)\cdot u(f(h^1)) \\ & < u(f(h^0)(1-c(\bar{h}(h^0)))) - (1-\pi)\cdot u(f(h^0)) \end{aligned}$$

□

D.4 Proof of Proposition 4

Proof of Proposition 4. Note that with the assumptions of stationarity above (i.e. that the lowest acceptable transfer of human capital at I is $\tilde{h}$), one can rewrite the parent's decision problem as:

$$\begin{aligned} U(h') &= \max_{h'} u(f(h)(1-c(h'))) \\ &\quad +\lambda\{(1-\pi)\cdot u(f(h')) + \pi \cdot u(f(h') - I) \\ &\quad +\beta u(f(h')(1-c(h'))) - u(f(h')) + \beta \cdot \pi \cdot I\} \end{aligned}$$

i.e. If $\exists h'$ at which the child finds it (weakly) optimal to honestly insure the parent and then choose insurance herself, her child will also find it weakly optimal to accept $h'' = h'$.

First Order Conditions with respect to h' suggest that:

$$\lambda = \frac{u'(f(h)(1-c(h')))f(h)c'(h')}{\pi \cdot u'(f(h') - \theta \cdot I)f'(h') - \pi \cdot u'(f(h')) + \beta \frac{\partial}{\partial h'} u(f(h')(1-c(h')))} > 0 \quad \text{(D.1)}$$

The denominator is the partial derivative of the child's surplus over cheating when $h' = h''$, which, by assumption, is positive.

If constrained first-best is achieved, then keeping λ constant and taking the partial derivative with respect to I:

$$\frac{\partial h'}{\partial I} = \frac{A}{B+C+D+E+F+G+H+J} \in (0,1)$$

Where

$A = \theta \cdot \lambda\pi \cdot u''(f(h') - \theta \cdot I)f'(h') < 0$

$B = -f(h)c''(h')u'(f(h)(1-c(h')))$

$C = (f(h)c'(h'))^2 \cdot u''(f(h)(1-c(h')))$

$D = -\lambda \cdot \pi \cdot u'(f(h'))f''(h')$

$E = -\lambda \cdot \pi \cdot u''(f(h'))(f'(h'))^2$

$F = \lambda \cdot \pi \cdot u'(f(h') - \theta \cdot I)f''(h')$

$G = \lambda \cdot \pi \cdot u''(f(h') - \theta \cdot I)(f'(h'))^2$

$H = \lambda \cdot \beta \cdot u'(f(h')(1 - c(h'))(f''(h') - 2f'(h')c'(h') - f'(h')c''(h'))$

$J = \lambda \cdot \beta \cdot u''(f(h')(1 - c(h'))(f'(h')(1 - c(h')))^2$

Since $u'(.) > 0, u''(.) < 0, f'(.) > 0, f''(.) < 0, c'(.) > 0, c''(.) < 0$ □

D.5 Proof of Proposition 5

Proof of Proposition 5. If constrained first-best is achieved, then keeping λ constant and taking the partial derivative with respect to θ, from Equation D.1:

$$\frac{\partial h'}{\partial \theta} = \frac{A}{B + C + D + E + F + G + H + J} \in (0, 1)$$

Where

$A = I \cdot \lambda\pi \cdot u''(f(h') - \theta \cdot I)f'(h') < 0$

$B = -f(h)c''(h')u'(f(h)(1 - c(h')))$

$C = (f(h)c'(h'))^2 \cdot u''(f(h)(1 - c(h')))$

$D = -\lambda \cdot \pi \cdot u'(f(h'))f''(h')$

$E = -\lambda \cdot \pi \cdot u''(f(h'))(f'(h'))^2$

$F = \lambda \cdot \pi \cdot u'(f(h') - \theta \cdot I)f''(h')$

$G = \lambda \cdot \pi \cdot u''(f(h') - \theta \cdot I)(f'(h'))^2$

$H = \lambda \cdot \beta \cdot u'(f(h')(1 - c(h'))(f''(h') - 2f'(h')c'(h') - f'(h')c''(h'))$

$J = \lambda \cdot \beta \cdot u''(f(h')(1 - c(h'))(f'(h')(1 - c(h')))^2$

Since $u'(.) > 0, u''(.) < 0, f'(.) > 0, f''(.) < 0, c'(.) > 0, c''(.) < 0$ □

D.6 Proof of Proposition 6

Proof of Proposition 6. If constrained first-best is achieved, then keeping λ constant and taking the partial derivative with respect to π, using Equation D.1:

$$\frac{\partial h'}{\partial \pi} = \frac{A'}{B' + C' + D' + E' + F' + G' + H' + J'}$$

Where

$A = \lambda f'(h')[u'(f(h')) - u'(f(h') - \theta I)] < 0$

$B = -f(h)c''(h')u'(f(h)(1 - c(h')))$

$C = (f(h)c'(h'))^2 \cdot u''(f(h)(1 - c(h')))$

$D = -\lambda \cdot \pi \cdot u'(f(h'))f''(h')$

$E = -\lambda \cdot \pi \cdot u''(f(h'))(f'(h'))^2$

$F = \lambda \cdot \pi \cdot u'(f(h') - \theta \cdot I)f''(h')$

$G = \lambda \cdot \pi \cdot u''(f(h') - \theta \cdot I)(f'(h'))^2$

$H = \lambda \cdot \beta \cdot u'(f(h')(1 - c(h'))(f''(h') - 2f'(h')c'(h') - f'(h')c''(h'))$

$J = \lambda \cdot \beta \cdot u''(f(h')(1 - c(h'))(f'(h')(1 - c(h')))^2$

Since $u'(.) > 0, u''(.) < 0, f'(.) > 0, f''(.) < 0, c'(.) > 0, c''(.) < 0$ □

Appendix E

Figures: Chapter 2

Figure E.1 Maximum Human Capital Transferred to Child: h=.18

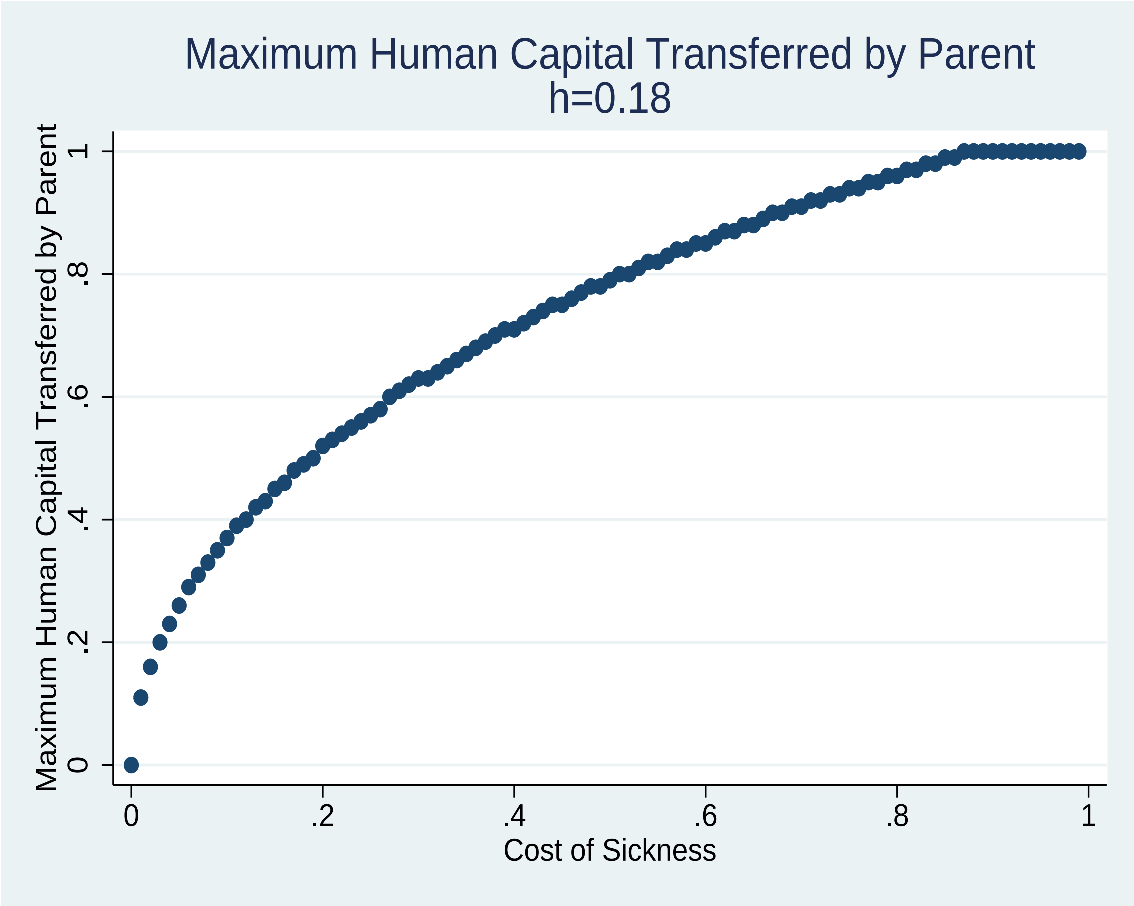


Figure E.2 Maximum Human Capital Transferred to Child: h=.5

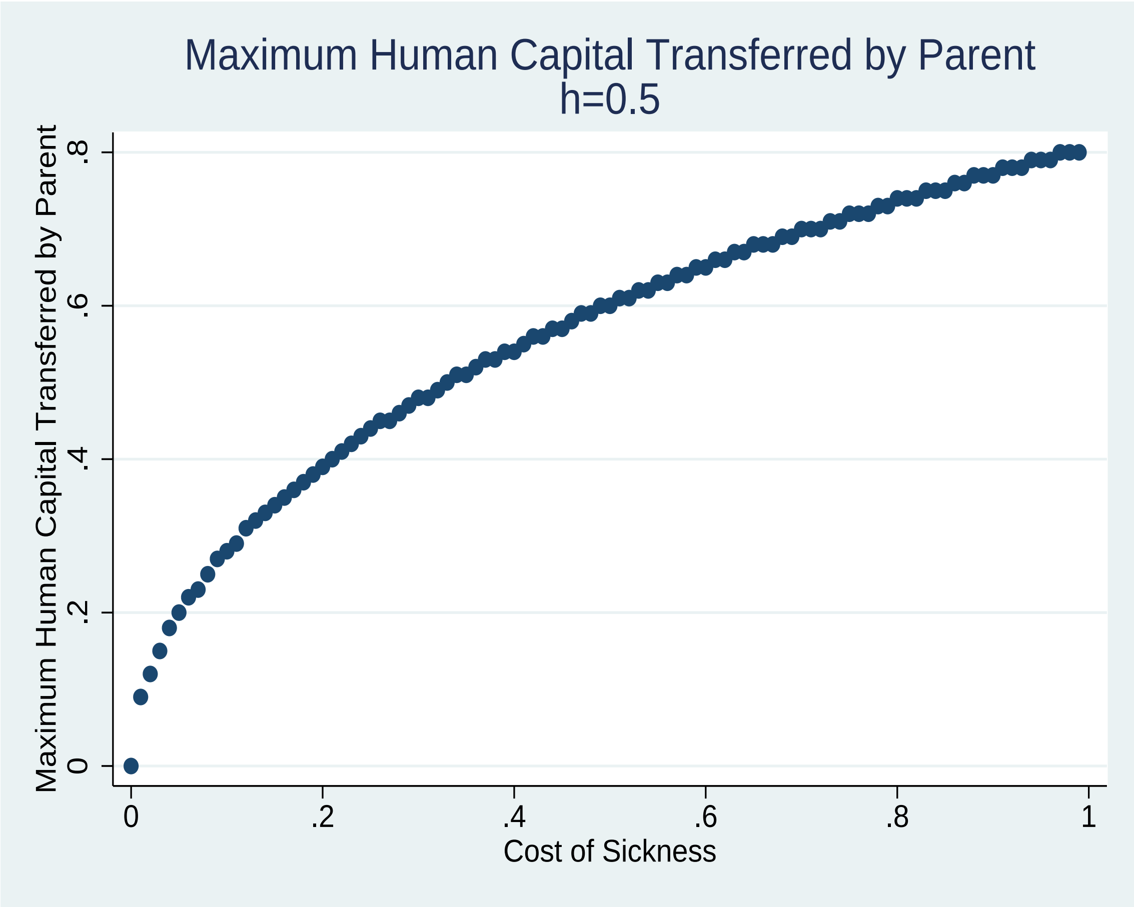


Figure E.3 Maximum Human Capital Transferred to Child: I=0.01

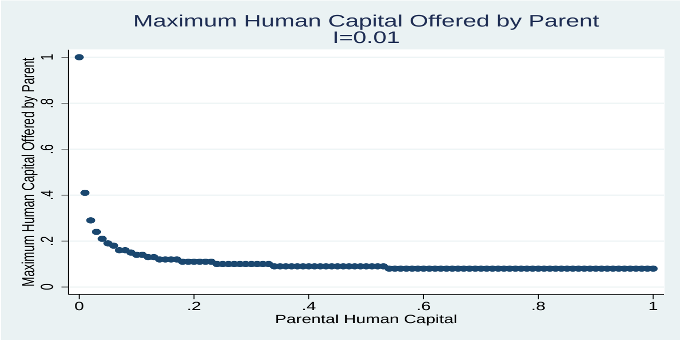


Figure E.4 Maximum Human Capital Transferred to Child: I=0.5

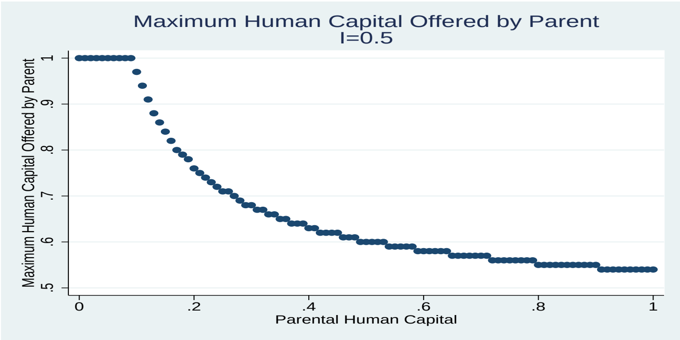


Figure E.5 Maximum Human Capital Transferred to Child: I=0.99

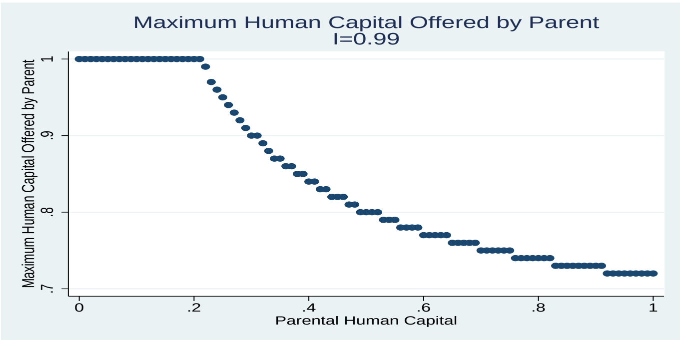


Figure E.6 Maximum Human Capital Transfer

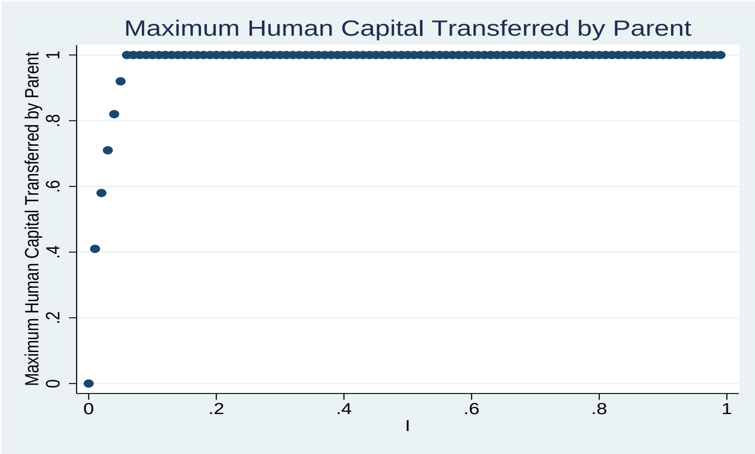


Figure E.7 Lower Bound of Maximum Human Capital Transfer

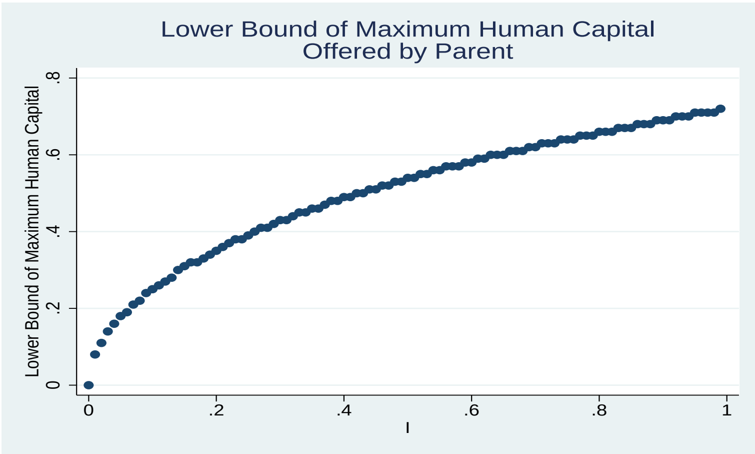


Figure E.8 Minimum Human Capital Transfer Accepted by Child

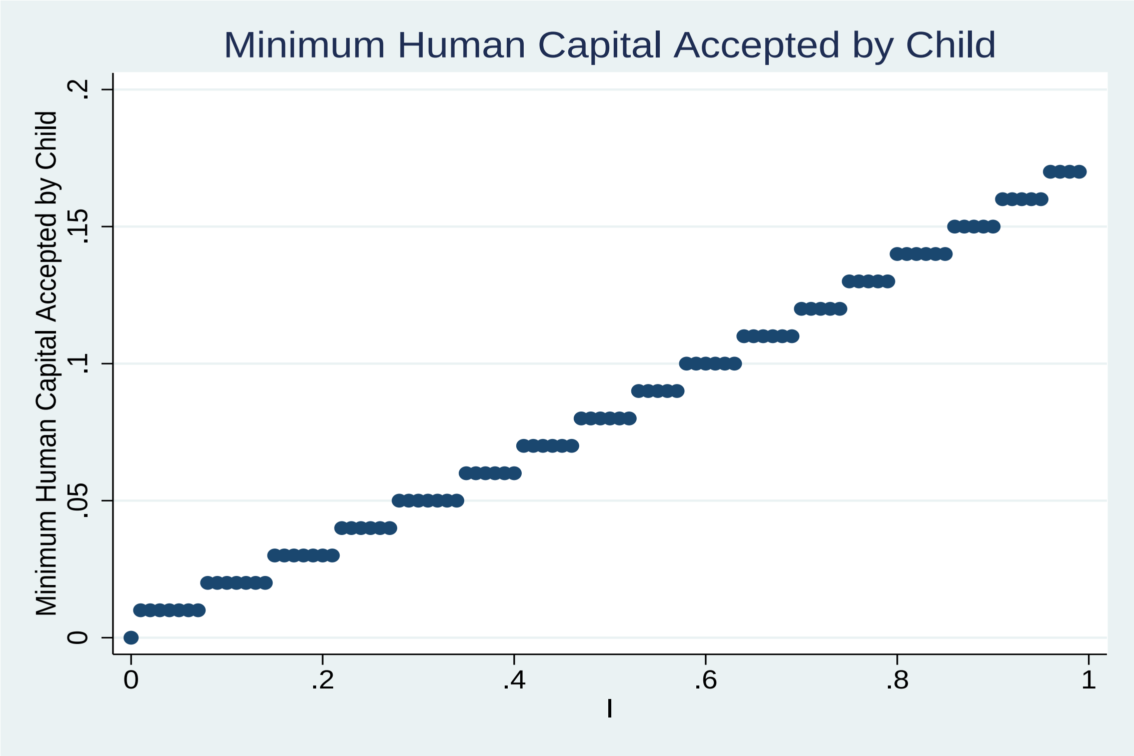
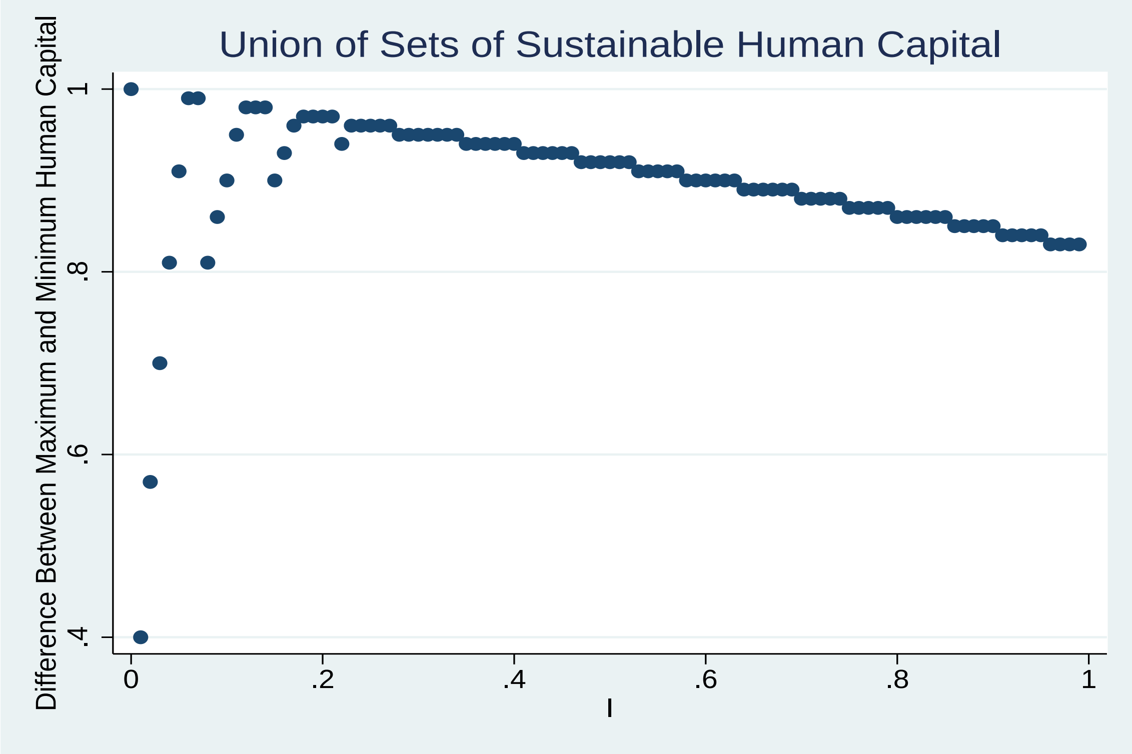


Figure E.9 Difference Between Maximum and Minimum Sustainable Human Capital Transfers



Appendix F

Figures: Chapter 3

Figure F.1 Cross Country Variation in Growth of High-skilled Wage Bill Shares and ICT Intensity, 1980- 2004

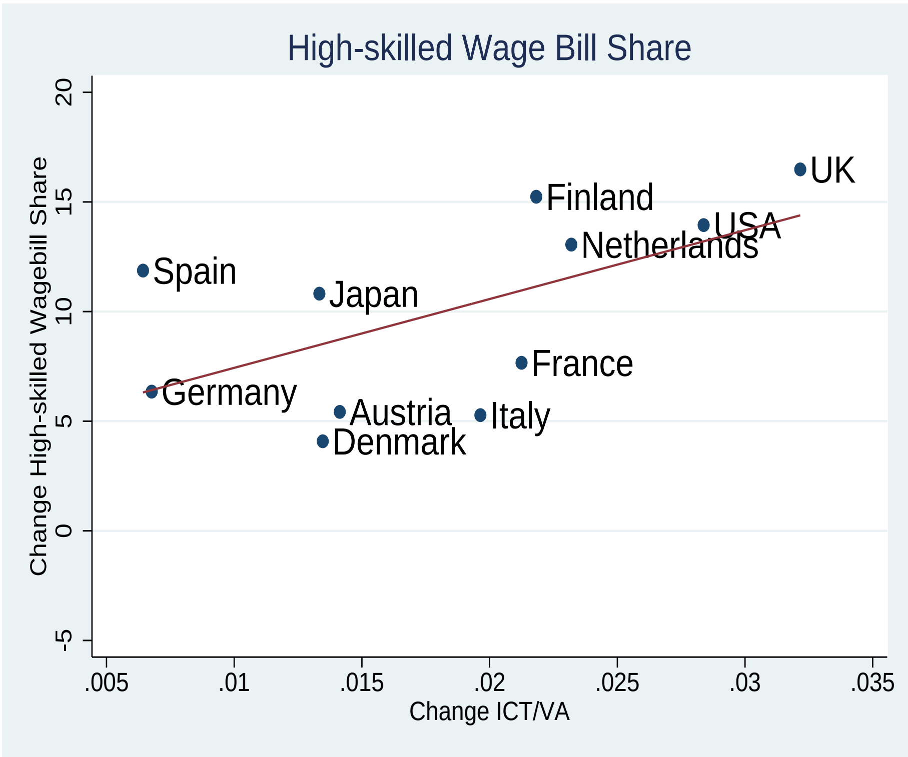


Figure F.2 Cross Country Variation in Growth of Medium-skilled Wage Bill Shares and ICT Intensity, 1980- 2004

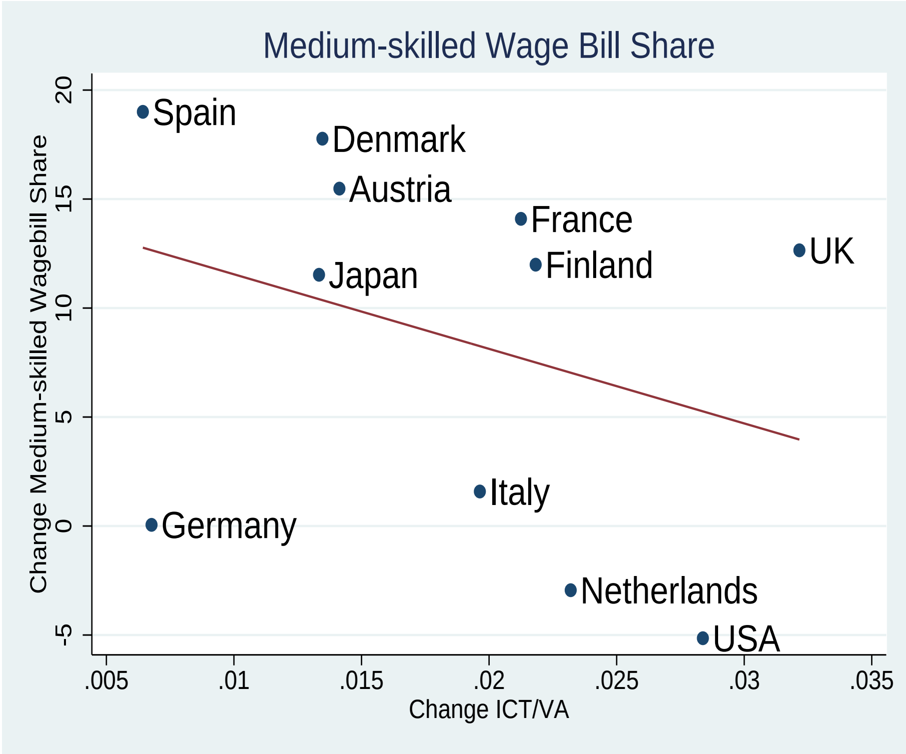


Figure F.3 Cross Country Variation in Growth of Low-skilled Wage Bill Shares and ICT Intensity, 1980- 2004

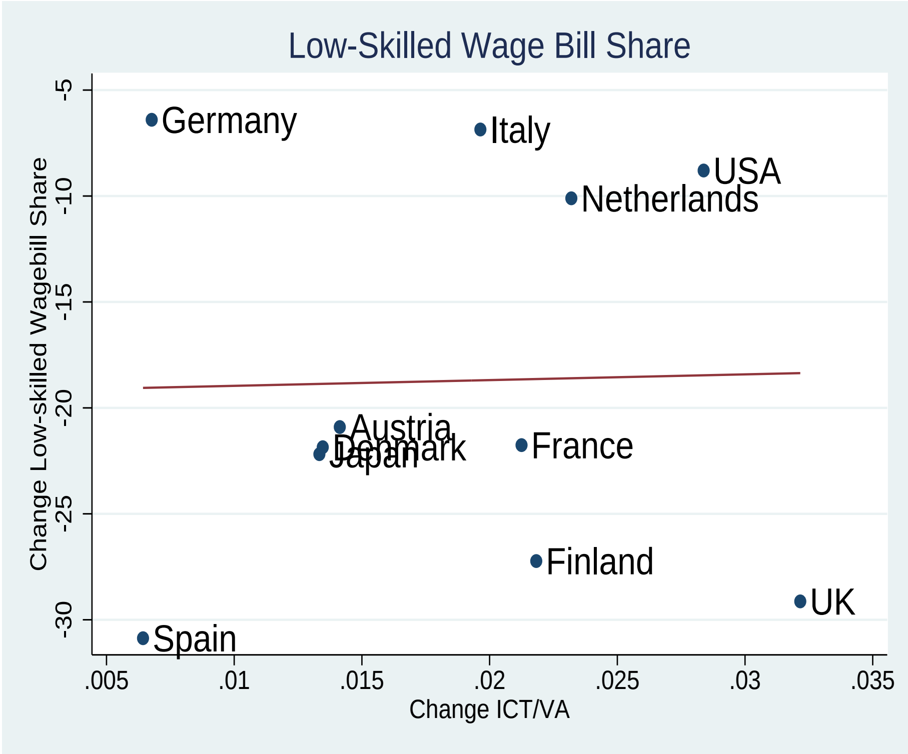


Figure F.4 Average Annual Percentage Point Changes in High, Medium and Low-Skilled Wage Bill Shares over Six- Year Intervals from 1980-2004 (Eleven Country Average)

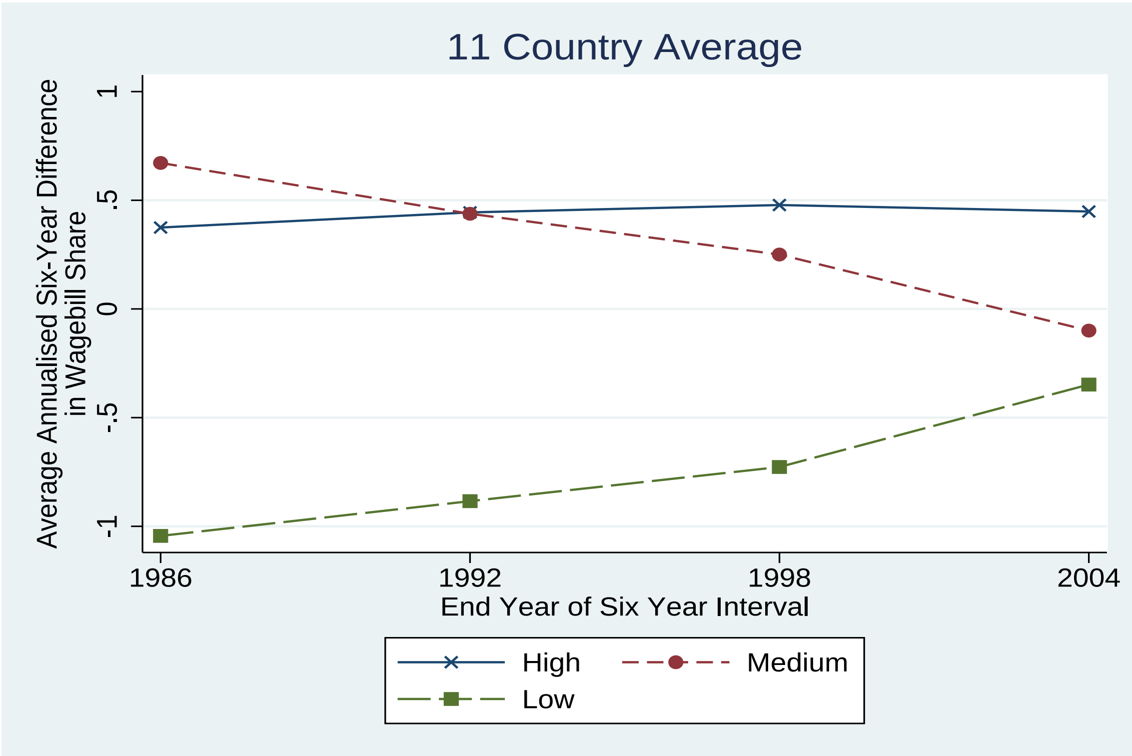


Figure F.5 Average Annual Percentage Point Changes in High, Medium and Low-Skilled Wage Bill Shares over Six- Year Intervals from 1980-2004 (U.S. Average)

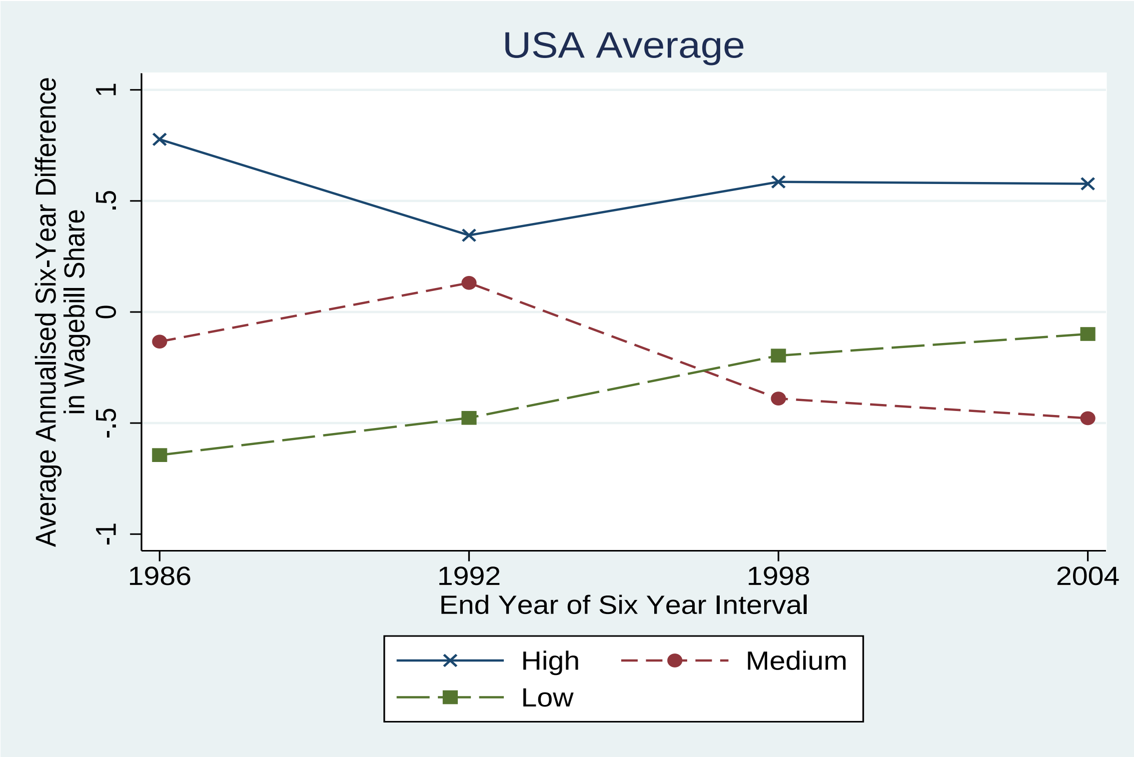


Figure F.6 Cross-Industry Variation in Growth of High-Skilled Wage-Bill Share and ICT Intensity, 1980-2004 (11 Country Means: Whole Economy)

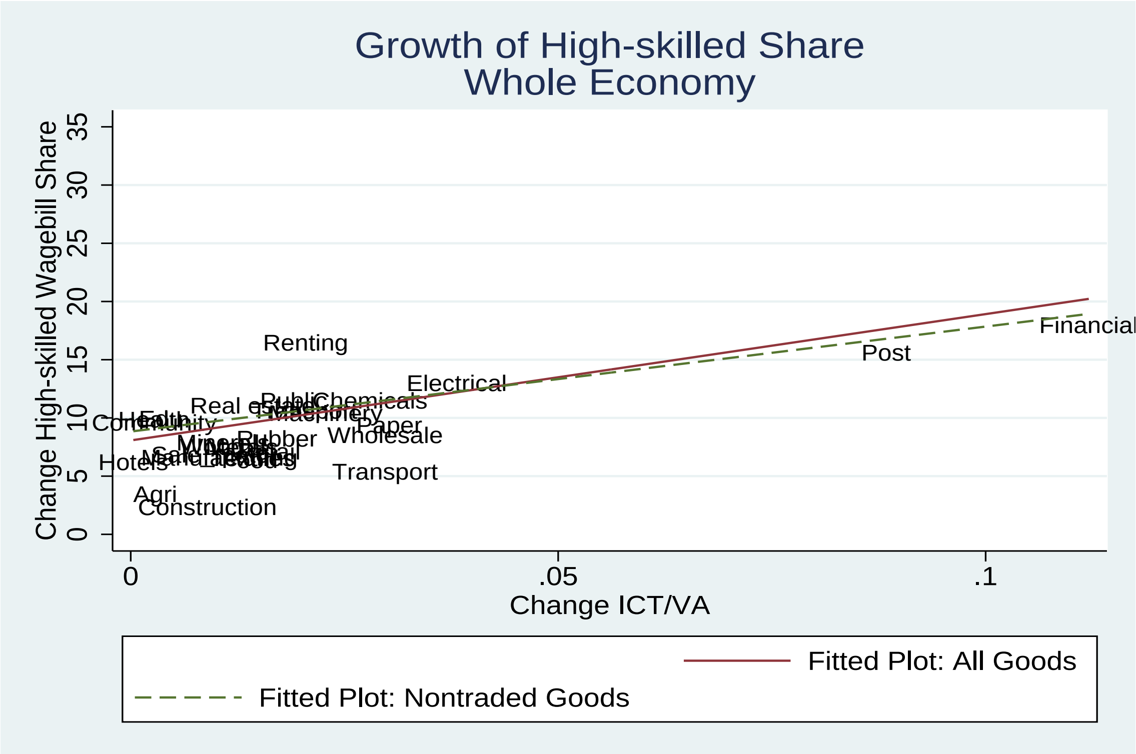


Figure F.7 Cross-Industry Variation in Growth of High-Skilled Wage-Bill Share and ICT Intensity, 1980-2004 (11 Country Means: Traded Goods Only)

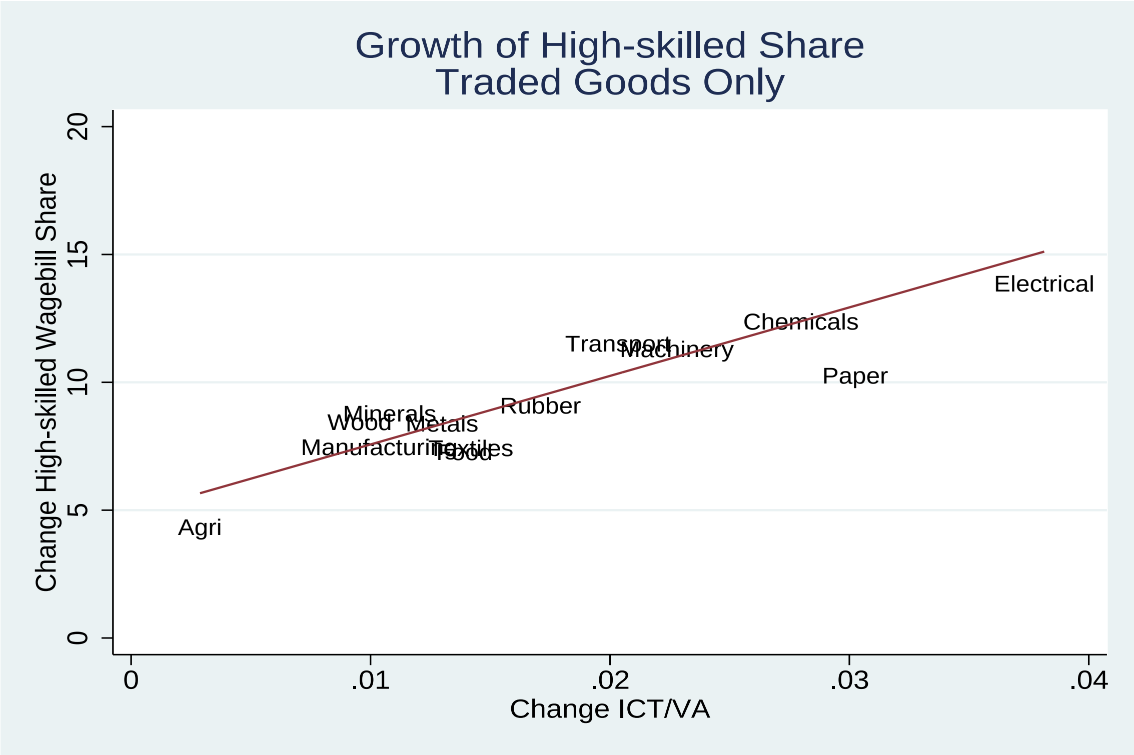


Figure F.8 Cross-Industry Variation in Growth of Medium-Skilled Wage-Bill Share and ICT Intensity, 1980-2004 (11 Country Means: Whole Economy)

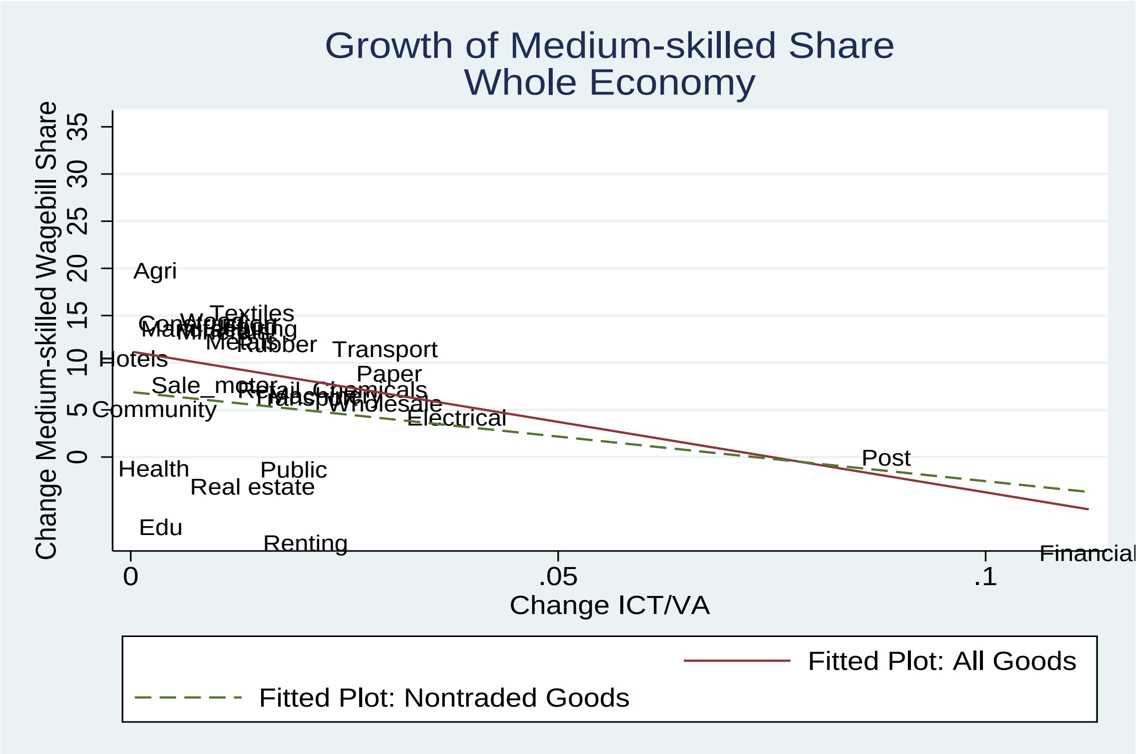


Figure F.9 Cross-Industry Variation in Growth of Medium-Skilled Wage-Bill Share and ICT Intensity, 1980-2004 (11 Country Means: Traded Goods Only)

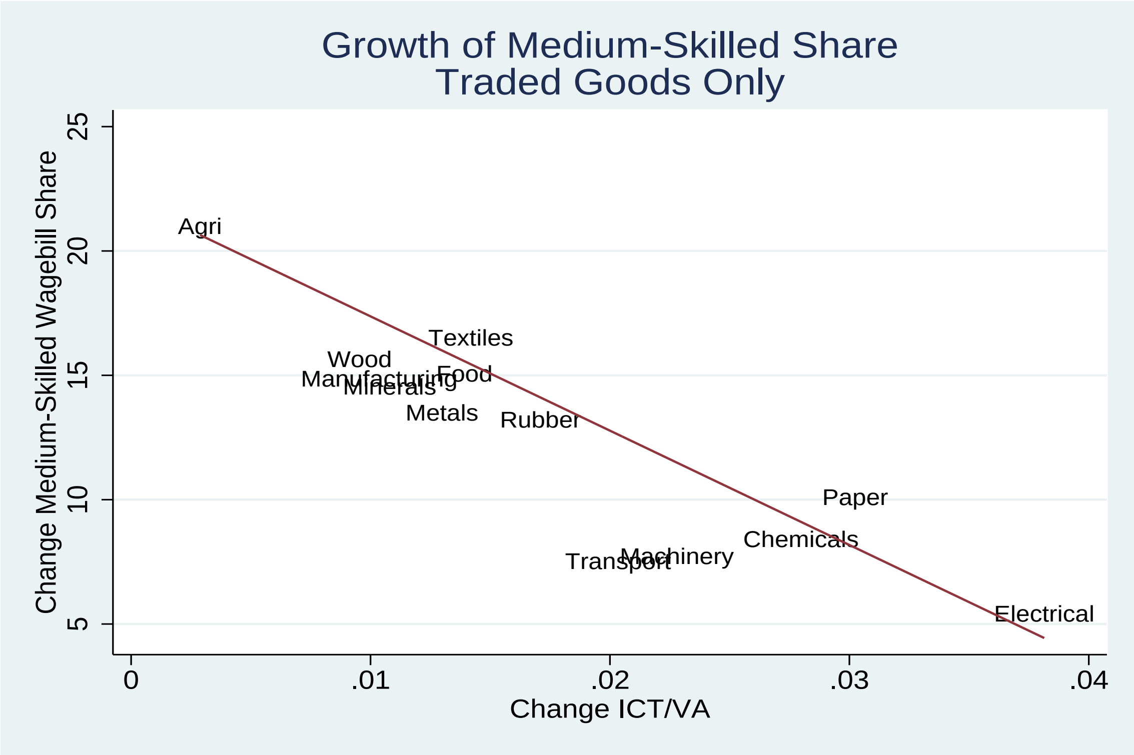


Figure F.10 Cross-Industry Variation in Growth of Low-Skilled Wage-Bill Share and ICT Intensity, 1980-2004 (11 Country Means: Whole Economy)

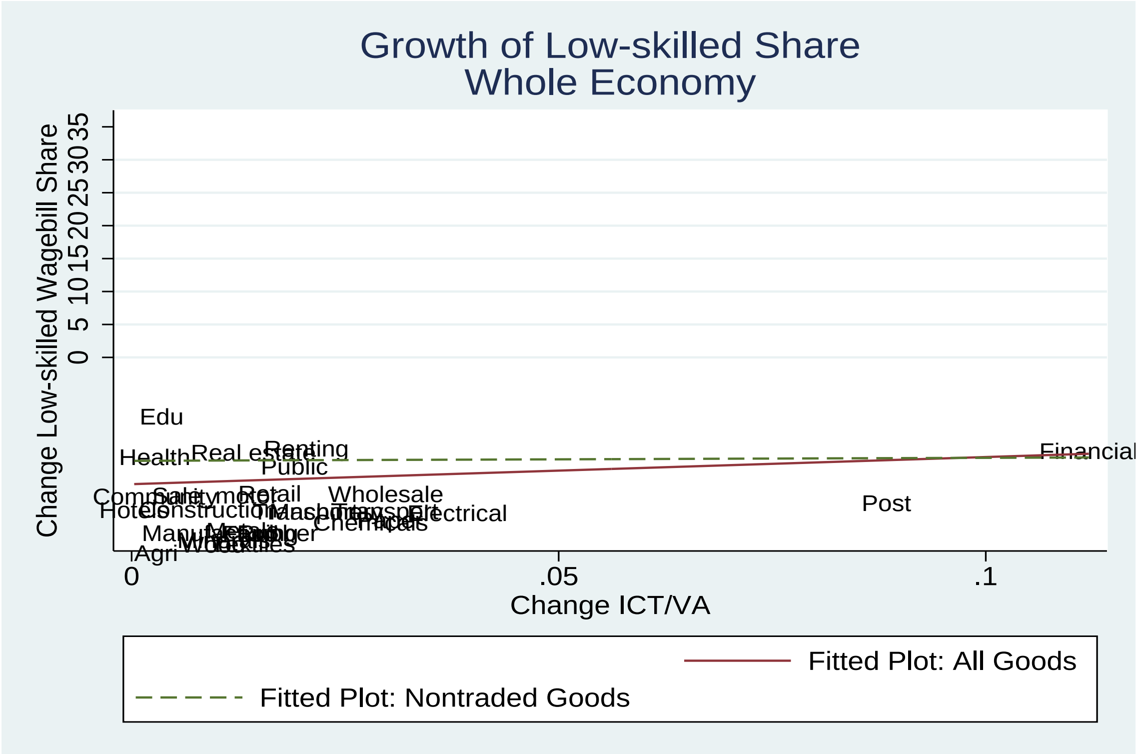
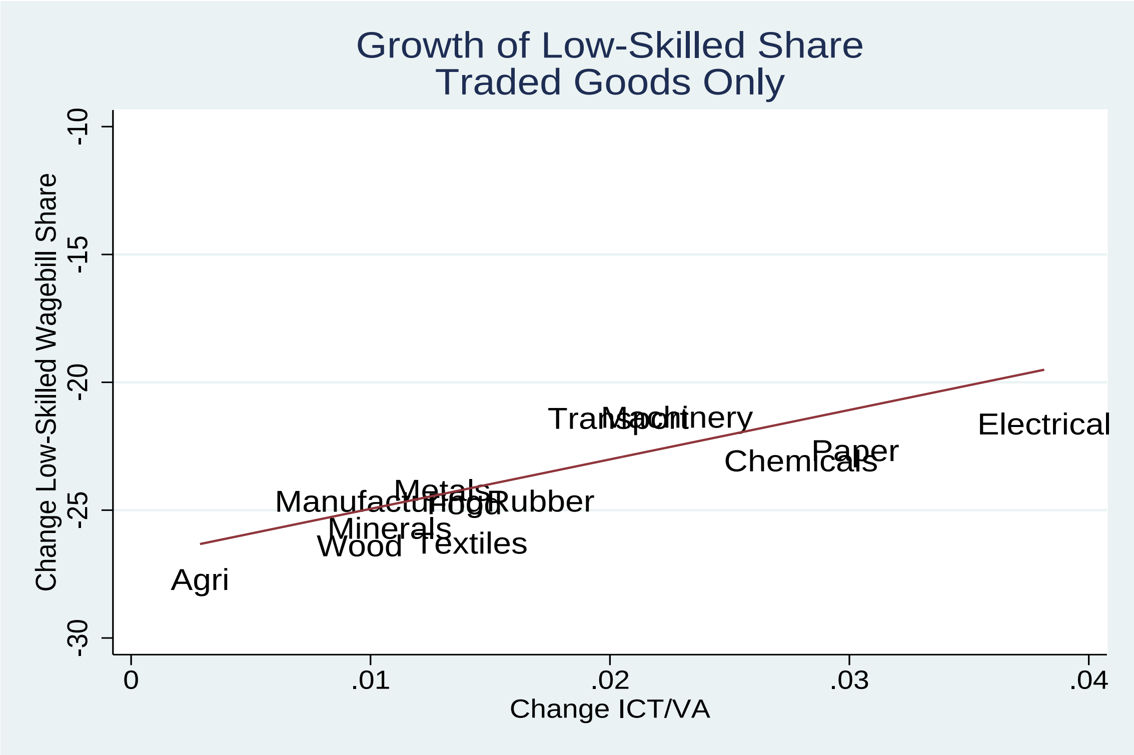


Figure F.11 Cross-Industry Variation in Growth of Low-Skilled Wage-Bill Share and ICT Intensity, 1980-2004 (11 Country Means: Traded Goods Only)



Appendix G

Tables: Chapter 3

Table G.1: Mean Standardized Scores by skill group - 1980 US data

			High-Skilled	Middle-Skilled	Low-Skilled
Routine Tasks	Cognitive	Set limits, Tolerances or Standards	-0.32	0.06	0.07
	Manual	Finger Dexterity	-0.21	0.13	-0.14
Non-routine tasks	Cognitive	Quantitative reasoning requirements	0.79	-0.02	-0.43
		Direction, Control and Planning	0.90	-0.11	-0.32
	Manual	Eye-Hand-Foot coordination	-0.36	-0.04	0.29

Note: This table reports the mean standardized task measures by skill group, using 1980 US Census micro data and the occ8090 classification from Autor, Levy, and Murnane (2003). For each task measure, the standardized measure is derived by subtracting from each occupation's task score the weighted mean task score across all occupations, and then dividing the difference by the standard deviation of the task measure across the 453 occupations.

Table G.2: Top occupations by share of workers of different skill levels, with task measures

						Standardised Task measures				
						Routine		Non-routine		
						Cognitive	Manual	Cognitive		Manual
occ8090	Occupation	Employment	Fraction	Fraction	Fraction	Set Limits, Tolerances	Finger	Quantitative	Direction, Control	Eye, Hand
	Description	in 1980	High-skilled	Middle-skilled	Low-skilled	and Standards	Dexterity	Reasoning Requirements	and Planning	Foot Coordination
					Top 10 occupations by share of high-skilled workers					
84	Physicians	460,260	0.97	0.03	0.00	-0.96	4.18	1.94	1.87	0.50
178	Lawyers	534,780	0.95	0.05	0.00	-0.96	-1.11	1.05	-0.51	-0.80
85	Dentists	135,620 0.94	0.06	0.00	1.47	4.73	1.99	-0.55	0.89	
133	Medical science teachers	9,860	0.93	0.06	0.01	-1.05	-0.90	1.73	2.08	-0.80
126	Social science teachers, n.e.c.	2,480	0.93	0.04	0.03	-1.05	-1.12	2.01	2.33	-0.80
146	Social work teachers	1,060	0.92	0.06	0.02	-1.05	-1.12	2.01	2.33	-0.80
123	History teachers	6,380	0.92	0.06	0.02	-1.05	-1.12	1.73	2.17	-0.80
118	Sociology teachers;Psychology teachers	9,200	0.92	0.06	0.02	-1.05	-1.12	2.01	2.33	-0.80
147	Theology teachers	3,940	0.91	0.07	0.03	-1.05	-1.12	1.97	2.27	-0.80
86	Veterinarians	37,440	0.91	0.08	0.01	1.00	4.06	0.96	-0.52	-0.71
					Top 10 occupations by share of middle-skilled workers					
314	Stenographers	106,360	0.07	0.88	0.05	1.40	1.13	-0.58	-0.64	-0.80
529	Telephone installers and repairers	273,980	0.03	0.87	0.10	1.45	1.38	0.47	-0.60	2.16
383	Bank tellers	639,180	0.07	0.86	0.07	1.48	2.53	0.29	-0.49	-0.80
313	Secretaries	5,020,140	0.08	0.86	0.07	-0.71	2.73	0.17	-0.61	-0.79
385	Data-entry keyers	472,880	0.05	0.85	0.10	1.31	0.23	0.08	0.16	-0.76
206	Radiologic technicians	110,060	0.10	0.85	0.04	1.51	0.98	1.13	-0.59	0.92
527	Telephone line installers and repairers	65,560	0.03	0.85	0.12	1.32	1.06	0.34	-0.37	1.80
315	Typists	969,040	0.05	0.84	0.11	-0.06	1.50	-0.12	-0.63	-0.76
338	Payroll and timekeeping clerks	200,940	0.06	0.83	0.11	1.47	0.79	0.05	-0.52	-0.80
525	Data processing equipment repairers	48,140	0.10	0.83	0.06	1.43	1.19	0.81	-0.34	-0.70
					Top 10 occupations by share of low-skilled workers					
407	Private household cleaners and servants	569,980	0.02	0.27	0.71	-1.05	-1.12	-0.86	-0.58	0.54
488	Graders and sorters, agricultural products	40,100	0.01	0.30	0.69	-0.04	-0.42	-0.87	-0.49	0.78
404	Cooks, private household	18,460	0.03	0.30	0.67	-1.05	-1.12	-0.80	-0.38	-0.14
747	Pressing machine operators	145,740	0.01	0.33	0.67	-0.91	0.16	-1.47	-0.66	0.42
405	Housekeepers and butlers	101,220	0.02	0.32	0.65	-1.05	-1.12	-0.83	0.04	0.28
738	Winding and twisting machine operators	140,080	0.01	0.35	0.65	0.51	0.69	-1.46	-0.61	-0.11
403	Launderers and Ironers	3,160	0.02	0.34	0.65	-1.05	-1.12	-1.49	-0.66	0.25
479	Farm workers	1,337,020	0.03	0.33	0.64	-0.03	-0.39	-0.87	-0.49	0.78
443	Waiters'/waitresses' assistants	422,800	0.01	0.36	0.62	-1.01	-0.98	-1.34	-0.64	0.73
449	Maids and housemen	969,720	0.01	0.36	0.62	-0.98	-1.05	-1.33	-0.47	0.38

Note: This table reports the top 10 occupations for each of the three skill categories, along with mean standardized task measures, using 1980 US Census micro data and the occ8090 classification from Autor, Levy, and Murnane (2003).
For each task measure, the standardized measure is derived by subtracting from each occupation's task score the weighted mean task score across all occupations, and then dividing the difference by the standard deviation of the task measure across the 453 occupations.

Table G.3: Summary Statistics by Country

Panel A: 1980 levels averaged by country							
Country	(1) (High-skilled wage-bill share)	(2) (Medium-skilled wage-bill share)	(3) (Low-skilled wage-bill share)	(4) ln(Value Added)	(5) ((ICT capital) / (Value Added))	(6) ((Non ICT capital) / (Value Added))	(7) ((Imports+Exports) / (Value Added))
Austria	8.8	51.6	39.6	8.0	0.012	0.227	1.43
Denmark	5.3	50.5	44.2	7.8	0.029	0.174	2.24
Finland	26.9	28.5	44.6	7.6	0.015	0.195	1.36
France	11.2	49.6	39.2	10.1	0.011	0.158	1.23
Germany	9.4	66.0	24.7	10.3	0.020	0.168	1.31
Italy	5.8	86.9	7.3	9.7	0.021	0.174	0.91
Japan	17.7	49.0	33.2	10.8	0.016	0.230	0.55
Netherlands	21.6	62.1	16.3	8.8	0.012	0.155	3.39
Spain	12.7	9.6	77.7	9.1	0.021	0.265	0.53
UK	9.2	52.7	38.1	9.8	0.019	0.180	1.54
USA	28.7	56.0	15.3	11.6	0.016	0.224	0.54
Mean	14.3	51.1	34.6	9.4	0.018	0.195	1.4

Panel B: Changes from 1980-2004 averaged by country							
Country	Δ (College wage-bill share)	Δ (Medium-skilled wage-bill share)	Δ (Low-skilled wage-bill share)	Δ ln(Value Added)	Δ ((ICT capital) / (Value Added))	Δ((Non ICT capital) / (Value Added))	Δ((Imports+Exports) / (Value Added))
Austria	5.4	15.5	-20.9	1.2	0.014	0.010	0.87
Denmark	4.1	17.8	-21.9	1.3	0.013	-0.011	1.26
Finland	15.2	12.0	-27.2	1.2	0.022	-0.001	0.36
France	7.7	14.1	-21.8	1.1	0.021	0.066	0.99
Germany	6.3	0.1	-6.4	1.1	0.007	0.023	1.03
Italy	5.3	1.6	-6.9	1.2	0.020	0.051	0.55
Japan	10.8	11.5	-22.3	1.1	0.013	0.035	0.33
Netherlands	13.1	-2.9	-10.1	1.3	0.023	0.041	3.01
Spain	11.9	19.0	-30.9	1.5	0.006	0.056	1.13
UK	16.5	12.6	-29.1	1.3	0.032	-0.031	1.26
USA	13.9	-5.1	-8.8	1.4	0.028	0.032	0.62
Mean	10.0	8.7	-18.8	1.2	0.018	0.025	1.04

Note: The table reports means weighted by 1980 share of each country's employment. All variables are measured for the full sample, except for trade variables, measured only for traded goods.

Table G.4: Summary Statistics by Industry: 1980 levels

	1980 levels averaged by industry							Mean weight (share of 1980 employment) across countries	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Code Description	High-skilled wage-bill share	Medium-skilled wage-bill share	Low-skilled wage-bill share	ln(Value Added)	((ICT capital) / (Value Added))	((Non ICT capital) / (Value Added))	((Imports+Exports) / (Value Added))	Full sample	Traded goods only
Agriculture, hunting, forestry and fishing	5.9	39.7	54.4	9.49	0.002	0.246	0.73	0.10	0.28
Food products, beverages and tobacco	6.4	47.7	45.9	9.12	0.012	0.341	1.09	0.03	0.09
Textiles, textile products, leather and footwear	5.0	45.8	49.2	8.60	0.006	0.168	2.13	0.03	0.09
Wood and products of wood and cork	7.8	46.8	45.4	7.53	0.010	0.232	2.30	0.01	0.03
Pulp, paper, paper products, printing and publishing	10.8	51.4	37.8	8.75	0.021	0.242	0.84	0.02	0.07
Chemicals and chemical products	13.3	49.2	37.4	8.67	0.016	0.370	2.51	0.01	0.04
Rubber and plastics products	9.0	49.1	41.9	7.81	0.010	0.255	0.42	0.01	0.02
Other non-metallic mineral products	8.6	47.4	44.0	8.14	0.014	0.270	0.57	0.01	0.03
Basic metals and fabricated metal products	8.7	50.1	41.2	9.22	0.010	0.267	1.01	0.03	0.10
Machinery, not elsewhere classified	9.8	55.7	34.5	8.92	0.017	0.209	1.59	0.03	0.08
Electrical and optical equipment	12.6	54.7	32.7	8.88	0.024	0.176	3.78	0.03	0.08
Transport equipment	10.5	54.9	34.5	8.58	0.010	0.167	1.35	0.02	0.06
Manufacturing not elsewhere classified; recycling	7.0	47.7	45.3	8.02	0.013	0.213	3.21	0.01	0.04
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	6.5	59.6	33.9	8.49	0.016	0.195		0.02	
Wholesale trade and commission trade, except of motor vehicles and motorcycles	10.2	57.1	32.6	9.70	0.032	0.247		0.05	
Retail trade, except of motor vehicles and motorcycles; repair of household goods	8.3	58.1	33.6	9.55	0.011	0.084		0.09	
Transport and storage	6.1	53.7	40.2	9.56	0.020	0.200		0.04	
Post and telecommunications	8.1	60.5	31.4	8.65	0.143	0.238		0.02	
Real estate activities	26.8	52.4	20.8	9.85	0.014	0.891		0.01	
Renting of machinery and equipment and other business activities	29.3	51.2	19.5	9.53	0.051	0.180		0.05	
Construction	7.3	52.1	40.6	9.98	0.005	0.180		0.08	
Hotels and restaurants	6.2	54.4	39.4	8.78	0.013	0.136		0.04	
Financial intermediation	18.3	65.0	16.6	9.49	0.051	0.297		0.03	
Public admin and defence; compulsory social security	20.8	58.4	20.7	9.96	0.017	0.171		0.07	
Education	51.7	38.2	10.1	9.58	0.013	0.078		0.06	
Health and social work	27.0	53.1	19.8	9.58	0.011	0.119		0.07	
Other community, social and personal services	18.4	50.1	31.5	9.07	0.038	0.215		0.04	

Note: The table reports means weighted by 1980 share of each country's employment. All variables are measured for the full sample, except for trade variables, measured only for traded goods.

Table G.5: Summary Statistics by Industry: Changes from 1980-2004

	Changes from 1980-2004 averaged by industry							Mean weight (share of 1980 employment) across countries	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Code Description	Δ (High-skilled wage-bill share	Δ (Medium-skilled wage-bill share	Δ (Low-skilled wage-bill share	Δ ln(Value Added)	Δ ((ICT capital) / (Value Added))	Δ ((Non ICT capital) / (Value Added))	Δ ((Imports+Exports) / (Value Added))	Full sample	Traded goods only
Agriculture, hunting, forestry and fishing	5.1	21.8	-26.9	0.56	0.003	0.009	0.25	0.10	0.28
Food products, beverages and tobacco	8.0	15.8	-23.9	1.00	0.014	0.010	0.29	0.03	0.09
Textiles, textile products, leather and footwear	8.2	17.3	-25.4	0.16	0.014	0.027	3.79	0.03	0.09
Wood and products of wood and cork	9.2	16.4	-25.5	0.93	0.010	0.020	0.02	0.01	0.03
Pulp, paper, paper products, printing and publishing	11.0	10.9	-21.8	1.17	0.030	0.047	0.02	0.02	0.07
Chemicals and chemical products	13.1	9.2	-22.2	1.22	0.028	0.070	1.18	0.01	0.04
Rubber and plastics products	9.8	14.0	-23.8	1.28	0.017	0.022	0.04	0.01	0.02
Other non-metallic mineral products	9.5	15.3	-24.9	0.90	0.011	0.052	0.13	0.01	0.03
Basic metals and fabricated metal products	9.1	14.3	-23.4	0.97	0.013	0.009	0.18	0.03	0.10
Machinery, not elsewhere classified	12.0	8.5	-20.5	1.05	0.023	-0.003	0.98	0.03	0.08
Electrical and optical equipment	14.6	6.2	-20.8	1.23	0.038	0.052	5.42	0.03	0.08
Transport equipment	12.3	8.3	-20.6	1.11	0.020	0.080	0.94	0.02	0.06
Manufacturing not elsewhere classified; recycling	8.2	15.6	-23.8	1.05	0.010	0.004	0.41	0.01	0.04
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	8.5	9.7	-18.1	1.3	0.0	0.0		0.02	
Wholesale trade and commission trade, except of motor vehicles and motorcycles	10.2	7.7	-17.8	1.42	0.030	0.055		0.05	
Retail trade, except of motor vehicles and motorcycles; repair of household goods	8.7	9.1	-17.8	1.29	0.016	0.079		0.09	
Transport and storage	7.0	13.5	-20.5	1.36	0.030	0.072		0.04	
Post and telecommunications	17.2	1.9	-19.2	1.60	0.088	0.119		0.02	
Real estate activities	12.7	-1.1	-11.6	1.81	0.014	-0.008		0.01	
Renting of machinery and equipment and other business activities	18.1	-7.1	-11.0	2.16	0.020	-0.027		0.05	
Construction	4.0	16.2	-20.2	1.19	0.009	0.013		0.08	
Hotels and restaurants	7.8	12.5	-20.3	1.59	0.000	0.041		0.04	
Financial intermediation	19.6	-8.2	-11.3	1.57	0.112	0.009		0.03	
Public admin and defence; compulsory social security	13.1	0.7	-13.7	1.30	0.019	-0.022		0.07	
Education	11.6	-5.4	-6.1	1.47	0.004	-0.010		0.06	
Health and social work	11.5	0.8	-12.2	1.70	0.003	-0.008		0.07	
Other community, social and personal services	11.2	7.1	-18.3	1.65	0.003	0.029		0.04	

Note: The table reports means weighted by 1980 share of each country's employment. All variables are measured for the full sample, except for trade variables, measured only for traded goods.

Table G.6: Changes in Wage Bill Shares: 1980-2004

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A:Dependent variable: High-Skilled Wage Bill Share								
Δ ((ICT capital)		72.29***	64.56***	46.92***		163.94***	139.6***	128.71***
/ (Value Added))		(18.28)	(17.31)	(14.94)		(45.48)	(42.74)	(32.19)
Δ ln(Value Added)			5.42***	4.76***			3.26	3.41***
			(1.24)	(0.95)			(2.25)	(1.07)
Δ ((Non ICT capital)			-7.64	-6.45*			0.31	-0.47
/ (Value Added))			(4.92)	(3.51)			(5.59)	(2.45)
Intercept	10.02***	8.69***	2.22		9.12***	6.42***	4.04*	
	(0.57)	(0.63)	(1.67)		(0.86)	(1.02)	(2.19)	
Country fixed effects				X				X
Sample: All industries	X	X	X	X				
Sample: Traded industries					X	X	X	X
Obs.	208	208	208	208	84	84	84	84
R-squared		0.09	0.19	0.45		0.19	0.22	0.81
Panel B:Dependent variable: Medium-Skilled Wage Bill Share								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ ((ICT capital))		-100.78***	-77.76***	-64.52***		-163.98	-41.59	-288.01***
/ (Value Added)		(30.21)	(25.44)	(20.24)		(115.77)	(84.73)	(83.94)
Δ ln(Value Added)			-13.8***	-15.33***			-15.64***	-7.96**
			(2.69)	(2.23)			(4.27)	(3.14)
Δ ((Non ICT capital)			9.76	18.01*			-10.79	1.57
/ (Value Added))			(11.88)	(10.25)			(14.08)	(10.98)
Intercept	8.73***	10.59***	27.24***		15.5***	18.20***	29.75***	
	(1.29)	(1.49)	(3.73)		(1.90)	(2.95)	(4.67)	
Country fixed effects				X				X
Sample: All industries	X	X	X	X				
Sample: Traded industries					X	X	X	X
Obs.	208	208	208	208	84	84	84	84
R-squared		0.05	0.23	0.58		0.05	0.25	0.74
Panel C:Dependent variable: Low-Skilled Wage Bill Share								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ ((ICT capital))		28.55	13.21	17.71		0.50	-97.91	159.65**
/ (Value Added)		(27.34)	(25.66)	(16.41)		(113.51)	(100.71)	(79.30)
Δ ln(Value Added)			8.43***	10.62***			12.45***	4.61
			(2.40)	(1.95)			(4.24)	(3.30)
Δ ((Non ICT capital)			-2.21	-11.68			10.32	-1.28
/ (Value Added))			(9.63)	(9.07)			(11.91)	(11.73)
Intercept	-18.74***	-19.26***	-29.5***		-24.61***	-24.62***	-33.84***	
	(1.12)	(1.31)	(3.27)		(1.68)	(2.55)	(3.95)	
Country fixed effects				X				X
Sample: All industries	X	X	X	X				
Sample: Traded industries					X	X	X	X
Obs.	208	208	208	208	84	84	84	84
R-squared		0.00	0.10	0.65		0.00	0.16	0.70

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: Coefficients estimated by OLS with robust standard errors in parentheses.
Columns (1)-(4) are estimated on all industries and columns (5)-(8) are on the tradable sectors.

Weights in columns (1)-(4): each industry's 1980 share of each country's employment.

Weights in columns (5)-(8):each industry's 1980 share of each country's employment in traded industries.

Table G.7: Changes in Wage Bill Shares: 1980-2004 - Robustness checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Dependent variable: High-Skilled Wage Bill Share										
	OLS	OLS	OLS	OLS	OLS	OLS	2SLS	2SLS	2SLS	2SLS
Δ ((ICT capital)	46.92***	42.09***	50.98***	48.79***	132.84**	66.1	121.63**	103.16**	137.99	65.31
/ (Value Added))	(14.94)	(14.66)	(16.64)	(16.20)	(52.59)	(58.15)	(53.43)	(48.82)	(119.44)	(104.60)
Δ ln(Value Added)	4.76***	2.93**	5.79***	4.4**	0.26	-1.97	4.24***	4.85***	4.12***	5.09***
	(0.95)	(1.39)	(1.31)	(1.93)	(2.94)	(3.79)	(1.07)	(1.10)	(1.30)	(1.20)
Δ ((Non ICT capital)	-6.45*	-5.06	-9.25**	-8.19	15.41	2.56	-8.47**	-9.85**	-8.91*	-8.54
/ (Value Added))	(3.51)	(3.99)	(4.56)	(5.13)	(12.99)	(12.94)	(4.02)	(4.33)	(5.01)	(5.16)
1980 High-skilled		0.06		0.04		0.34*				
wage bill share		(0.06)		(0.07)		(0.19)				
1980 Medium-skilled		0.12**		0.08		0.6**				
wage bill share		(0.05)		(0.07)		(0.27)				
Country fixed effects	X	X	X	X			X	X	X	X
Sample	All	All	Continental Europe	Continental Europe	USA	USA	All	All except USA	All	All except USA
Obs.	208	208	143	143	27	27	208	181	208	181
R-squared	0.45	0.47	0.44	0.45	0.21	0.43	0.36	0.38	0.32	0.46
F-stat for excluded instrument in the first stage							10.5	9.6	6.5	8.3
Panel B: Dependent variable: Medium-Skilled Wage Bill Share										
	OLS	OLS	OLS	OLS	OLS	OLS	2SLS	2SLS	2SLS	2SLS
Δ ((ICT capital)	-64.52***	-41.72***	-62.13***	-51.41***	-160.15***	-80.06	-73.81	-46.74	-42.8	22.21
/ (Value Added))	(20.24)	(13.35)	(18.79)	(14.28)	(44.52)	(60.97)	(56.75)	(49.04)	(235.73)	(224.74)
Δ ln(Value Added)	-15.33***	-2.73	-16.33***	-4.36	-7.57**	0.45	-15.26***	-16.24***	-15.48***	-16.67***
	(2.23)	(1.99)	(3.13)	(2.83)	(3.32)	(3.64)	(2.30)	(2.47)	(2.27)	(2.34)
Δ ((Non ICT capital)	18.01*	3.89	21.33	7.82	-16.58	-7.9	18.26*	20.02*	17.42	17.62
/ (Value Added))	(10.25)	(6.61)	(13.38)	(9.27)	(17.77)	(13.85)	(10.59)	(11.41)	(11.34)	(12.81)
1980 High-skilled		-0.55***		-0.48***		-0.72***				
wage bill share		(0.08)		(0.08)		(0.19)				
1980 Medium-skilled		-0.64***		-0.57***		-0.95***				
wage bill share		(0.07)		(0.09)		(0.28)				
Country fixed effects	X	X	X	X			X	X	X	X
Sample	All	All	Continental Europe	Continental Europe	USA	USA	All	All except USA	All	All except USA
Obs.	208	208	143	143	27	27	208	181	208	181
R-squared	0.58	0.79	0.59	0.77	0.36	0.68	0.58	0.78	0.58	0.52
F-stat for excluded instrument in the first stage							10.5	9.6	6.5	8.3

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: Coefficients estimated by OLS with robust standard errors in parentheses. Regressions weighted by the industry's 1980 share of each country's employment. In columns (7) and (8) we instrument the 25-year difference in ICT Capital/Value Added by the 1980 levels of ICT capital/Value Added in the USA. In columns (9) and (10) we instrument the 25-year difference in ICT Capital/Value Added by the 1980 levels of routine task input using the 1991 Directory of Occupational Titles (constructed as in Autor, Levy and Murnane (2003)).

Table G.8: Decomposing Changes in Relative Wage Bills into Wages and Hours

Dependent Variable	Ln(Relative Wage Bill)				Ln(Relative Wages)				Ln(Relative Hours Worked)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	(High-skilled/Medium-skilled)		(Medium-skilled/Low-skilled)		(High-skilled/Medium-skilled)		(Medium-skilled/Low-skilled)		(High-skilled/Medium-skilled)		(Medium-skilled/Low-skilled)	
Δ ((ICT capital)	4.72***	4.00***	-2.47**	-2.04**	1.28***	0.93**	-0.62	-0.77	3.44**	3.07**	-1.85	-1.28
/ (Value Added))	(1.36)	(1.26)	(1.07)	(0.99)	(0.48)	(0.43)	(0.60)	(0.68)	(1.33)	(1.26)	(1.14)	(1.12)
Δ ln(Value Added)		0.18*		-0.28***		0.10*		0.04		0.08		-0.32***
		(0.09)		(0.08)		(0.06)		(0.07)		(0.09)		(0.10)
Δ ((Non ICT capital)		0.98*		0.14		0.41*		0.18		0.57		-0.03
/ (Value Added))		(0.51)		(0.38)		(0.21)		(0.17)		(0.51)		(0.34)
Country fixed effects	X	X	X	X	X	X	X	X	X	X	X	X
Sample: All industries	X	X	X	X	X	X	X	X	X	X	X	X
Obs.	208	208	208	208	208	208	208	208	208	208	208	208
R-squared	0.32	0.38	0.72	0.75	0.28	0.33	0.43	0.44	0.32	0.33	0.52	0.56

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Dependent variable in columns (1)-(4) is the 1980-2004 change in the Ln(relative wage bill) e.g. in column (1) this is ln(wage bill of highly skilled workers) - ln(wage bill of medium skilled workers). The dependent variable in columns (5)-(8) is the change in Ln(relative hourly wage) e.g. in column (5) it is the ln(hourly wage of highly skilled) - ln(hourly wage of medium skilled). In columns (9)-(12) the dependent variable is the change in Ln(relative hours worked) e.g. in column (9) this is ln(annual hours of highly skilled) - ln(annual hours of medium skilled). Coefficients estimated by OLS with robust standard errors in parentheses. Regressions weighted by the industry's 1980 share of each country's employment.

Table G.9: Trade and Technology

Panel A: Dependent variable: High-Skilled Wage Bill Share										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Δ ((Imports+ Exports))	0.59	0.71***	0.59***	0.50**	0.24	0.11				
/ (Value Added))	(0.46)	(0.25)	(0.15)	(0.19)	(0.30)	(0.25)				
Δ ((ICT capital)			107.61***	94.25***		73.59**	75.49**	47.21***	96.63***	72.37**
/ (Value Added))			(31.70)	(34.07)		(31.41)	(31.10)	(15.20)	(33.05)	(30.80)
Δ ln(Value Added)			4.09***	3.84***	4.03***	2.57*	2.36*	5.61***	4.16***	2.98*
			(1.09)	(1.26)	(1.38)	(1.52)	(1.35)	(1.05)	(1.30)	(1.52)
Δ ((Non ICT capital)			-0.63	0.16		0.97	1.03	-6.23*	0.06	0.85
/ (Value Added))			(2.41)	(3.41)		(3.12)	(3.02)	(3.51)	(3.45)	(3.18)
1980 (Research and Development					34.18*	28.04	30.08**			25.76
Expenditure/Value Added)					(18.23)	(17.59)	(14.91)			(16.00)
Δ (Imported								16.40**	8.78**	4.27
Intermediate inputs)								(7.00)	(3.47)	(2.82)
Intercept	8.6***									
	(0.60)									
Country fixed effects		X	X	X	X	X	X	X	X	X
Sample: Traded goods (all countries)	X	X	X							
Sample: Traded goods (except Austria and Spain)				X	X	X	X		X	X
Sample: All goods (all countries)								X		
Obs.	84	84	84	65	65	65	65	208	65	65
R-squared	0.02	0.67	0.82	0.80	0.80	0.82	0.82	0.46	0.76	0.78
Panel B: Dependent variable: Medium-Skilled Wage Bill Share										
Δ ((Imports+ Exports))	-1.18	-1.26*	-0.95*	-0.95*	-0.77	-0.49				
/ (Value Added))	(0.91)	(0.75)	(0.57)	(0.52)	(0.63)	(0.52)				
Δ ((ICT capital)			-253.80***	-294.15***		-269.46***	-277.86***	-64.78***	-309.49***	-274.20***
/ (Value Added))			(83.12)	(69.28)		(69.36)	(69.49)	(20.44)	(69.40)	(69.54)
Δ ln(Value Added)			-9.07**	-7.07**	-9.34***	-5.55*	-4.61*	-16.08***	-7.06**	-5.34
			(3.42)	(2.92)	(3.18)	(3.18)	(2.64)	(2.56)	(3.12)	(3.31)
Δ ((Non ICT capital)			1.84	24.10**		23.14**	22.86**	17.81*	24.22**	23.07**
/ (Value Added))			(10.75)	(10.03)		(10.59)	(10.62)	(10.16)	(10.25)	(10.72)
1980 (Research and Development					-60.72**	-33.51*	-42.55**			-37.47**
Expenditure/Value Added)					(25.89)	(19.24)	(17.22)			(18.20)
Δ (Imported								-14.49	-11.58	-5.02
Intermediate inputs)								(13.56)	(9.87)	(7.93)
Intercept	16.52***									
	(2.21)									
Country fixed effects		X	X	X	X	X	X	X	X	X
Sample: Traded goods (all countries)	X	X	X							
Sample: Traded goods (except Austria and Spain)				X	X	X	X		X	X
Sample: All goods (all countries)								X		
Obs.	84	84	84	65	65	65	65	208	65	65
R-squared	0.02	0.55	0.75	0.81	0.73	0.82	0.81	0.58	0.76	0.77

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Coefficients estimated by OLS with robust standard errors in parentheses. Regressions weighted by the industry's 1980 share of each country's employment, for traded goods (columns 1-7) and for all goods (column 8). The OECD ANBERD dataset does not have R&D data for Austria and Spain, which are dropped from the sample (columns (4)-(7)). In column 8, we construct the imported intermediate inputs measure by using the 1987 Input/Output Tables for USA, and taking the product of the relative use by each industry of all commodities and the ratio of Total Imports to Apparent Consumption (Output+Imports-Exports) of each industry.

Table G.10: List of all EUKLEMS Industries

Code	Code Description
	Manufacturing
AtB	Agriculture, hunting, forestry and fishing
C	Mining and quarrying
15t16	Food products, beverages and tobacco
17t19	Textiles, textile products, leather and footwear
20	Wood and products of wood and cork
21t22	Pulp, paper, paper products, printing and publishing
23	Coke, refined petroleum products and nuclear fuel
24	Chemicals and chemical products
25	Rubber and plastics products
26	Other non-metallic mineral products
27t28	Basic metals and fabricated metal products
29	Machinery, not elsewhere classified
30t33	Electrical and optical equipment
34t35	Transport equipment
36t37	Manufacturing not elsewhere classified; recycling
	Services
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52	Retail trade, except of motor vehicles and motorcycles; repair of household goods
60t63	Transport and storage
64	Post and telecommunications
70	Real estate activities
71t74	Renting of machinery and equipment and other business activities
E	Electricity, gas and water supply
F	Construction
H	Hotels and restaurants
J	Financial intermediation
L	Public administration, defence, and compulsory social security
M	Education
N	Health and social work
O	Other community, social and personal services

Table G.11: List of Industries Pooled by Country

	NACE Codes
Austria	15t16 plus 17t19 plus 36t37; 20 plus 21t22 plus 24 plus 25 plus 26 plus 27t28; 29 plus 30t33 plus 34t35; 50 plus 51 plus 52 plus H; 60t63; 64; 70 plus 71t74; AtB; F; J; L; M; N; O
Denmark	15t16; 17t19; 36t37; 20; 21t22; 24; 25; 26; 27t28; 29; 30t33; 34t35; 50; 51; 52; H; 60t63; 64; 70; 71t74; AtB; F; J; L; M; N; O
Finland	15t16 plus 17t19 plus 36t37; 20 plus 21t22 plus 24 plus 25 plus 26 plus 27t28; 29 plus 30t33 plus 34t35; 50 plus 51 plus 52 plus H; 60t63; 64; 70 plus 71t74; AtB; F; J; L; M; N; O
France	15t16 plus 17t19 plus 36t37; 20 plus 21t22 plus 24 plus 25 plus 26 plus 27t28; 29 plus 30t33 plus 34t35; 50 plus 51 plus 52 plus H; 60t63; 64; 70 plus 71t74; AtB; F; J; L; M; N; O
Germany	15t16 plus 17t19; 20 plus 21t22 plus 24 plus 25 plus 26 plus 27t28 plus 29; 30t33 plus 34t35; 36t37; 50 plus 51 plus 52 plus H; 60t63 plus 64; 70 plus 71t74; AtB; F; J; L; M; N; O
Italy	15t16; 17t19; 20; 21t22;24; 25; 26; 27t28; 29; 30t33; 34t35; 36t37; 50; 51; 52; H; 60t63; 64; 70; 71t74; AtB; F; J; L; M; N; O
Japan	AtB; 20; 60t63; 64; H; 17t19; 26; 27t28; 50; 25 plus 36t37; 34t35; 15t16; O; 29; 52; 30t33; F; 21t22; 24; 71t74; 51; J; 70; L plus M plus N
Netherlands	AtB; F; 50 plus 51 plus 52 plus H; 64; 15t16 plus 17t19; 60t63; 20 plus 21t22 plus 24 plus 25 plus 26 plus 27t28 plus 36t37; J; 29 plus 30t33 plus 34t35; L; N; 70 plus 71t74; M; O
Spain	15t16; 17t19; 20 plus 21t22 plus 24 plus 25 plus 26 plus 27t28; 29; 30t33; 34t35; 36t37; 50 plus 51 plus 52; 60t63; 64; 70 plus 71t74; AtB; F; H; J; L; M; N; O
UK	64; F; 50 plus 51 plus 52 plus H; 15t16 plus 17t19 plus 36t37; AtB; 60t63; 20 plus 21t22 plus 24 plus 25 plus 26 plus 27t28; 29 plus 30t33 plus 34t35; O; L; J; N; 70 plus 71t74; M
USA	15t16; 17t19; 36t37; 20; 21t22; 24; 25; 26; 27t28; 29; 30t33; 34t35; 50; 51; 52; H; 60t63; 64; 70; 71t74; AtB; F; J; L; M; N; O

Table G.12: Trade, ICT, and Research and Development

	Dependent variable: High-Skilled Wage Bill Share																	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Δ ((Imports+ Exports))	0.59***	0.11																
/ (Value Added))	(0.15)	(0.25)																
Δ ((Imports))			1.07***	0.21														
/ (Value Added))			(0.30)	(0.45)														
Δ ((Exports))					1.16***	0.21												
/ (Value Added))					(0.30)	(0.54)												
Δ ((Imports OECD							0.68***	-0.05										
+ Exports OECD)) / (Value Added))							(0.18)	(0.37)										
Δ ((Imports OECD))									1.44***	-0.43								
/ (Value Added))									(0.52)	(0.91)								
Δ ((Exports OECD))											1.10***	0.03						
/ (Value Added))											(0.30)	(0.61)						
Δ ((Imports nonOECD													2.21***	1.38				
+ Exports nonOECD))/ (Value Added))													(0.58)	(0.73)				
Δ ((Imports nonOECD))															2.09***	1.14		
/ (Value Added))															(0.63)	(0.83)		
Δ ((Exports nonOECD))																	10.97***	9.30***
/ (Value Added))																	(3.38)	(3.41)
Δ ((ICT capital)	107.61***	73.59**	107.29***	73.22**	110.10***	74.17**	109.81***	76.19**	110.39***	78.75**	112.20***	75.32**	110.43***	69.95**	113.76***	71.89**	116.71***	67.65**
/ (Value Added))	(31.70)	(31.41)	(31.52)	(31.32)	(32.04)	(31.41)	(31.94)	(31.57)	(31.55)	(31.40)	(32.51)	(31.53)	(31.13)	(30.44)	(32.06)	(30.75)	(29.66)	(29.74)
Δ ln(Value Added)	4.09***	2.57*	4.30***	2.62*	3.80***	2.50*	3.94***	2.28	4.09***	2.01	3.74***	2.38	4.27***	3.07**	4.16***	2.86*	3.76***	3.04**
	(1.09)	(1.52)	(1.13)	(1.52)	(1.06)	(1.49)	(1.09)	(1.50)	(1.11)	(1.41)	(1.07)	(1.48)	(1.12)	(1.46)	(1.16)	(1.50)	(0.97)	(1.18)
Δ ((Non ICT capital)	-0.63	0.97	-0.50	0.99	-0.76	0.95	-0.46	1.04	0.00	0.90	-0.82	1.01	-1.10	0.61	-1.20	0.47	0.24	2.77
/ (Value Added))	(2.41)	(3.12)	(2.38)	(3.11)	(2.45)	(3.13)	(2.39)	(3.05)	(2.33)	(2.98)	(2.46)	(3.13)	(2.50)	(3.22)	(2.51)	(3.24)	(2.42)	(2.97)
1980 (Research and Development		28.04		28.05		28.27		30.89*		32.97*		29.83		25.38		26.73*		25.85*
Expenditure/Value Added)		(17.59)		(16.88)		(18.06)		(18.27)		(17.36)		(18.33)		(15.53)		(15.88)		(13.84)
Country fixed effects	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Obs.	84	65	84	65	84	65	84	65	84	65	84	65	84	65	84	65	84	65
R-squared	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.83	0.82	0.82	0.83	0.83

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Coefficients estimated by OLS with robust standard errors in parentheses.
Regressions weighted by the industry's 1980 share of each country's employment, for traded goods.
The OECD ANBERD dataset does not have R&D data for Austria and Spain, which are dropped from the sample (columns 2,4,6,8,10,12,14,16 and 18)

Table G.13: Contribution of Changes in ICT and R&D to Changes in the High-Skilled Wage Bill Share

	(1)	(2)	(3)	(4)	(5)	(6)
Sectors	All	All	Traded	Traded	All	All
Method	No Controls OLS	Full Controls OLS	No Controls OLS	Full Controls OLS	No controls IV	Full controls IV
Δ (High-Skilled Wagebill share	10.02	10.02	9.37	9.37	10.02	10.02
Δ ((ICT capital) / (Value Added))	0.018	0.018	0.017	0.017	0.018	0.018
Coefficient on ICT	72.3	46.9	83.1	75.5	152.3	121.6
Mean*Coefficient of ICT	1.32	0.86	1.45	1.31	2.78	2.22
Mean contribution % of ICT	13.16	8.50	15.43	14.03	27.72	22.14
Table and columns used	Table G.6 column (2)	Table G.6 column (4)		Table G.9 column (7)		Table G.7 column (7)
1980 (Research and Development Expenditure/Value Added)			0.028	0.028		
Coefficient on R&D			52.79	30.08		
Mean*Coefficient on R&D			1.49	0.85		
Mean contribution of R&D			15.90	9.06		

This table contains a "back of the envelope" calculation of the contribution of technology to accounting for the changes in the high-skilled wage bill share.

Appendix H

Data Appendix: Chapter 3

H.1 Construction of main dataset

Our main dataset is EUKLEMS (http://www.euklems.net/), which is an industry-level panel dataset created by economic researchers funded by the European Commission. It covers the European Union, the US, Japan, and other countries, and contains a wealth of information on productivity-related variables. These were constructed through joint work with census bureau in each country and are designed to be internationally comparable. Details of the methodology are in Timmer, van Moergastel, Stuivenwold, Ypma, O'Mahony, and Kangasniemi (2007), Timmer, Inklaar, O'Mahony, and van Ark (2010) and Timmer and O'Mahony (2009).

In the construction of our sample we faced a number of technical issues. First, although college wage bill shares are reported for 30 industries in each country, these reported wage bill shares are not unique within each country. For example, in a certain country the reported college wage bill share for industry A and industry B may be (college wage bill in A + college wage bill in B)/(total wage bill in A + total wage bill in B). The identity and number of industries pooled together vary across countries. In order to use as much of variation as possible, we aggregate industries within each country up to the lowest level of aggregation that ensures that the college wage bill share is unique across the aggregated observations. This is also sufficient to ensure that other variables we use, such as our ICT and value added measures, have unique values across observations.

Second, as a measure of ICT intensity we use ICT capital compensation divided by value added directly from EUKLEMs. ICT capital is built using the Perpetual Inventory method based on real ICT investment flows (using a quality-adjusted price deflator). ICT capital compensation is the stock of ICT capital multiplied by its user cost. Non-ICT capital compensation is built in the same way[1].

Third, matching trade variables into our main dataset required data required currency conversions, since EUKLEMS reports data in historical local currency and COMTRADE reports data in historical dollars. To overcome this difference, we convert nominal values to current US Dollars using exchange rates from the IMF IFS website. To convert national currency to the Euro (for Eurozone countries), we use exchange rates from the website:

http://ec.europa.eu/economy_finance/euro/transition/conversion_rates.htm

We use trade figures from the UN's COMTRADE dataset. Data is downloaded in the four digit Standard International Trade Classification format (revision 2), and converted to the European NACE Rev 1 classification used in the EUKLEMS dataset (concordance available on request). Our trade regressions contain the updated data from 21st March 2008.

To decompose trade into OECD versus non-OECD, we use the 2007 definition of OECD countries (Austria, Australia, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the UK and the USA). This means that Czechoslovakia and Belgium-Luxembourg were treated as OECD countries in 1980.

[1]Because EUKLEMS calculates capital compensation as a residual in a few cases observations can have negative capital compensation. Of the 208 country-industry cells we use, negative capital compensation occurs in 12 cases in 1980 and in 3 cases in 2004. These are typically agriculture (which is heavily subsidized and becomes smaller over time) and industries where public services play an important role (e.g. education and health). To overcome this problem, we bottom-coded negative values of ICT and non-ICT capital compensation to zero. Our results are robust to dropping these observations from the sample.

Finally, we account for the fact that the (aggregated) industries we use differ substantially in their employment shares within each country's population. We therefore use the employment shares of each industry in 1980 (our base year) in total employment as analytical weights in the regressions using both tradable and non-tradable industries. For trade regressions, which use only the traded industries, each industry's weight is its employment share in the traded industries for that country, so that the sum of weights for each country is still equal to one.

H.2 Construction of task measures by skill

To construct measures of task content by occupation and education group, which we use in Tables G.2 and G.1, we begin with US Census micro data for 1980 from IPUMS, which identify each person's occupation (using the three-digit 1980 occupation definitions from IPUMS) and education (measured in years of schooling completed). We assign each person to one of three educational categories - high, medium, or low - using the EUKLEMS classification for the US. In other words, high-skill workers are those who have at least 16 years of education, middle-skilled workers are those with 13-15 years of education, and low-skilled workers are those with 12 years of education. We then assign to each person the "80-90" occupation code using the concordance from Autor, Levy, and Murnane (2003), and we match to each occupation the task measures, which Autor, Levy, and Murnane (2003) derive from the 1991 Dictionary of Occupational Titles. These include routine cognitive tasks (measured using Set limits, Tolerances, or Standards); routine manual tasks (measured using Finger Dexterity); non-routine cognitive tasks measured using both (i) Quantitative reasoning requirements and (ii) Direction, Control, and Planning and non-routine manual tasks (measured using Eye-Hand-Foot coordination).

We then collapse the data to the occupation-skill level, using 1980 person weights from IPUMS. Finally, we standardize each of these five task measures by subtracting the mean task score across occupations, weighted by person weights, and dividing the resulting difference by the standard deviation of the task measure across occupations. The results in Tables G.2 and G.1 discussed below use these standardized task measures.

We calculate the intensity of occupation O in terms of skill level $S \in \{H, M, L\}$ as

$$Share_S^O = \frac{E_{OS}}{E_O},$$

where E_{oS} is the number of people in occupation O with skill level S, and E_O is the total number of people with occupation O. We then rank the occupations in terms of their intensity of each of the three skill groups, and Table 1 presents the ten top occupations in each skill category, and the score of each of these occupations on each task k.

Finally, we calculate the average score on each task k for each skill level S as

$$I_S^k = \sum_O \frac{E_{OS}}{E_S} I_o^k,$$

where I_O^k is occupation O's score on task k, E_{oS} is the number of people in occupation O with skill level S, and E_S is the total number of people with skill level S. These scores are reported in Table G.1.

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