ESSAYS ON EQUALITY AND PRODUCTIVITY

A Thesis submitted for the degree of

Doctor of Philosophy

at University of Leicester

by

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September 2016

DEDICATION

This dissertation is dedicated to my beloved wife Filagot Sileshi Tilahun without whose support it would not have been possible.

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Abstract

Understanding and enhancing productivity has been at the heart of sustainable growth goals of developing countries. Policy makers and multilateral agencies have inquired about what role the government can play in this regard. The empirical evidence at the micro level however, is surprisingly limited. This dissertation contributes to this literature by undertaking a firm and product level study of productivity. It estimates a causal effect of a typical industrial policy measure on total factor productivity and other firm outcomes. It also forwards a micro level explanation of the low productivity of capital despite its shortage in developing countries. We find that typical policy incentives like tax holiday and cheap loans targeted at firms in certain sectors and locations have negatively affected total factor productivity due to entry of less productive firms and diversification. We find that human capital, power and road infrastructure positively determine the productivity of capital.

The dissertation goes on to examine gender pay inequality by constructing a new measure from gender disaggregated labour share in value added. This measure is comparable across time and across countries. We also undertake a causal analysis of what determines gender pay inequality. We find that although gender pay inequality has been declining it is still substantial. In addition in some middle income countries income have to triple for gender pay gap to close.

ACKNOWLEDGEMENTS

Primarily, I thank the almighty God for he has made so many things possible. I want to express my deepest love and gratitude for my beloved wife Filagot Sileshi. She has been a rock for the family during this challenging journey. Her unrelenting support and sacrifice makes me forever indebted to her. I deeply love and thank you.

My deepest gratitude and thanks goes to my supervisor James Rockey for his enduring support in all respects. His unwavering dedication and commitment to the research and his insightful advice made the entire PhD journey worthwhile. You have truly inspired me to sharpen my inquiry skills and to meticulously scrutinize ideas. I am deeply grateful. I also would like to thank Martin Foureaux Koppensteiner and Subir Bose for their invaluable advice and support.

I want to express gratitude and appreciation to Tewodros Wodajo for supporting my enrollment in the program and for supporting me during the tough times of this journey.

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1. INTRODUCTION

Sustainable growth leading to structural transformation is considered to be a key requirement to achieve economic development. Productivity growth is deemed essential in achieving structural transformation. The past decade saw rapid economic growth in developing countries mainly driven by domestic demand and trade. Productivity in manufacturing firms in developing countries is not well understood at the firm level. This thesis contributes to the understanding of the productivity and role of different factors of production and tests the effectiveness of policy in enhancing total factor productivity.

Growth prescriptions by multilateral organizations for developing countries have included some form of industrialization policy. The efficacy of these policies have not been well understood especially at the firm level. The first chapters undertakes this challenge by offering alternative productivity estimates at the firm level using granular firm and product level data and by estimating the causal estimate of the effects of a typical industrial policy. We correct for various sources of bias in estimating productivity coefficients. We use Olley-Pakes and Levinson-Petrin methods of productivity estimation to account for the endogeneity of firm exit and input choice decisions in a setting where capital is not continuous. We recover productivity estimates for different product levels (1 product, 4 product and 8 products). We find that consistent with the Lucas Paradox capital has low productivity in spite of its short supply in developing countries. We explain why in the second chapter. We then estimate the effectiveness of an archetypal industrial policy where the government provides cheap loans and tax breaks to enhance investment in industries that yield high sectoral linkages. What if any effect will this have on productivity? We find that the policy didn't enhance productivity. Rather, we find that, the policy led to the entry of less productive firms that in turn led to the decline in average TFP. Furthermore the policy encouraged firms to invest in fungible assets to averse uncertainty caused by instability. We also do a back of the envelope calculation of the lower band of the cost of the policy. We

find that without much benefit the policy has a substantial cost.

The second chapter explains the low capital productivity in developing countries despite its shortage (Lucas Paradox). Various explanations have been forwarded in an attempt to explain the paradox. The bulk of the literature that explain the paradox are cross country studies mainly focussing on developed countries. We take a firm level approach that helps to account for heterogeniety in technology. We hypothesize that capital in developing countries requires better human capital and infrastructure to be productive. We utilize exogenous variation in human capital, power and roads to estimate their effect on productivity of capital. We utilize regional supply of technical and professional employees which we assume to be exogenous for small firms. We rule out interregional supply of professional and technical employees as labour market are segmented in the setting we look at. We find that human capital has a strong positive effect on the productivity of capital. We use the difference between night lights adjusted for frequency and night lights unadjusted for frequency to proxy for power outage and estimate the effect of power outage on productivity of capital. We find that outage significantly and negatively affects productivity of capital. In order to estimate the effect of roads we use the density of roads weighted by the variance in the land elevation. We assume that land elevation would exogenously vary the benefits obtained from the construction of roads. We find that roads significantly and positively affect productivity of capital.

Gender pay gap has been at the heart of policy discussion especially in advancing gender equality. One issue that is debated is the difference in the number of hours men and women work. The third chapter examines gender pay inequality in manufacturing across the world using a new measure of labour share by gender. The measure can be used to compare gender pay inequality across country and across time. The measure is based on gender disaggregated labour share. We compute the ratio of female labour share to male labour share by accounting for hours of work. We find that gender pay inequality has been improving but a big proportion of women in the world work for nothing. Our innovation is that we account for hours spent on work by self employed labour in a way that allows cross country comparisons. We also estimate the determinants of gender pay inequality using instrumental variable regression. We relate gender pay inequality with income and standard of living. We find that increases in income and an even more increase in living standard will be needed to achieve gender pay equality.

The chapter makes a contribution to the gender inequality and development literature.

2. THE EFFECTIVENESS OF INDUSTRIAL POLICY IN DEVELOPING COUNTRIES: CAUSAL EVIDENCE FROM ETHIOPIAN MANUFACTURING FIRMS

2.1 Introduction

Giving firms cheap loans and tax breaks is a common form of Industrial Policy (IP) in low-income countries (LICs). Despite their prevalence, the effectiveness of this form of IP is not well understood. This paper uses a product-level dataset for the universe of small and medium-sized Ethiopian manufacturing firms to study a typical policy.

This policy, which ran from 2002-2010, provided subsidised loans to small and medium-sized manufacturing firms in sectors chosen because of their intensive use of Ethiopian agricultural produce. It also provided tax breaks to firms more than 100km outside Addis Ababa. Despite the scepticism of many development economists, policies like this are common in LICs. However, there is little causal evidence as to whether and when they work. This paper uses exogenous geographic and sectoral variation in the form and the scale of the policy for identification. We show that the policy we study did not work. We then exploit detailed information on firms' investments and their products to show why not.

This type of IP focuses on reducing the cost of, and improving access to, capital. This has two main consequences. Firstly, some new firms that were not previously viable will enter the market, lowering average productivity. Secondly, existing firms will be able to invest in new capital equipment. The entry of new firms is expected to lead to agglomeration externalities. These will raise the productivity of all firms and more than compensate for the reduction in average productivity due to the entry of new low-productivity firms. Similarly, with access to additional

capital, existing firms will grow, attaining economies of scale and potentially moving into higher value-added production.

We show that the policy we study failed along both of these dimensions. It did lead to the entry of new firms, but these were too few and insufficiently productive to generate sufficient agglomeration externalities to increase average productivity. Similarly, whilst firms took advantage of concessionary loans they invested largely in stores of value, such as vehicles or buildings, rather than machinery.

Additional results show that this reflected local conditions. High inflation meant real interest rates on the concessionary loans were often negative, but the trading environment was volatile and there was no effective bankruptcy protection. Thus, a failed business might leave owners with a debt they were unable to pay back. A second factor is that our estimates suggest that the marginal product of capital was low meaning that firms were not constrained by a lack of capital – but by other factors.

Thus, this policy led to no increase in productivity, employment, or the stock of machinery. Yet, it was expensive. Forgone tax revenues alone were equivalent to 0.5% of GDP or 5% of annual government spending. For comparison, the entire manufacturing sector accounts only for 5% of GDP. This is true even assuming that the true effect of the policy was given by the upper 99% confidence bound of our estimate.

We focus on Ethiopia, but the policy we study is similar in form to those implemented in several other countries in Sub-Saharan Africa (SSA). Table 2.1 summarises the structure of the Industrial Policy of a selection of eight SSA countries as described by Marti and Ssenkubuge (2009). The table separates IP into three categories: Trade related policies, the literature on which is discussed below; Sector-Specific-Support, which is the focus of this paper; and inducements for Foreign Direct Investment, itself the subject of a large literature. Each of these policies is then categorised on the basis of whether it has a substantial Tax or Duty/Tariff component, and whether other forms of government support were provided. Considering the table as a whole reveals the broad consistency in the forms of IP implemented in these eight countries.[1] Focussing on sectoral support, all of the countries other than Cameroon provided support other than tax breaks to specific sectors.[2] Ethiopia is unusual in that it provides different reductions

[1] Specifics of these policies are provided in Table .6in Appendix A.2

[2] The precise form of the 'other' support varies; but it normally involves, as in Ethiopia, a

in tax depending on location. This is important as it means we can separate the effects of each aspect of the policy.

Tab. 2.1: Summary of Industrial Policy in Eight Subsaharan Africa Countries.

Country	Trade		Sectoral		FDI	
	Duty & Tarrif	Other	Tax	Other	Tax	Other
Botswana	✓			✓	✓	✓
Cameroon	✓	✓	✓			✓
Ethiopia	✓	✓	✓	✓	✓	✓
Ghana	✓		✓	✓	✓	✓
Kenya	✓	✓	✓	✓	✓	✓
Rwanda	✓			✓	✓	✓
South Africa	✓	✓		✓		✓
Uganda	✓			✓	✓	✓

Source: Marti and Ssenkubuge (2009)

This paper builds on previous work that estimates the causal effects of place-based policies, combinations of tax breaks and subsidies designed to stimulate output in economically depressed regions of rich nations. Busso et al. (2013) study the US Federal Empowerment Zone (EZ) program and find that it increased employment without costs in efficiency or effects on prices. Similarly, Criscuolo et al. (2016) find in their study of the impact of the EU Regional Selective Assistance scheme on UK firms that both employment and investment increased. Moreover, they too find that this happens at little cost to productivity. On the other hand Gobillon et al. (2012), studying the French EZ programme, find that the effects are small and transitory. Moreover, Neumark and Kolko (2010), who study a similar Californian policy, find it also was ineffective.

As well as a difference in context between rich countries such as the US and that of LICs such as Ethiopia, there is also a necessary difference in emphasis. In rich countries the emphasis is often on efficient transfers of income to poor areas or workers.[3] On the contrary, in LICs the aim is to acheive accelerated growth through raising TFP.[4] One way to think about this, given the cost of the policy

combination of concessionary loans, alongside infrastructure and training support.

[3] For example, Busso et al. (2013) write: "The conclusion of our welfare analysis is that the EZ program appears to have succesfuly transferred income to a small spatially concentrated labor force with modest deadweight losses aside from the usual cost of raising the funds for the subsidy itself."

[4] IP could also be effective if it led to growth through the reallocation of capital to more productive activities. In Section 2.6 we test for this and find no evidence of such effects.

we study was equivalent to at least 5% of government spending, is that to be sustainable LIC IP needs to generate sufficient growth to pay for itself.

Our focus on productivity is in common with the literature on another form of IP, protectionism and the cultivation of infant industries, which also has often focussed on less-developed countries. Harrison (1994) revisiting Krueger and Tuncer (1982) argued that sectors of Turkish manufacturing that had enjoyed more protection had (in fact) also exhibited faster productivity growth. By now, there is increasing support for the opposite conclusion. Specifically, Topalova and Khandelwal (2011) provide causal evidence that reduced tariffs in India led to improved firm-level productivity. Goldberg et al. (2010) show that the same reduction in tariffs led to an increase in the number of products available. Blonigen (2013) looks at the impact of protecting an important sector, in his case steel, on other sectors. He finds that there are large costs for sectors using steel. Of particular relevance for this paper is that he finds the costs of the policy are highest in LICs.

Other work has stressed that well-designed policy can be succesful. Harrison and Rodríguez-Clare (2010) review both the theoretical and empirical literature and suggest that there is little evidence that Industrial Policy based on tariffs, quotas and subsidies is effective. They do suggest, however, that more subtle policy may be successful. Nunn and Trefler (2010) provide quantitative evidence of such subtlety. They show that countries in which the tariff structure favours skill-intensive industries grow faster, but that three-quarters of this effect is due to the endogeneity between tariff-structures and domestic rent-seeking. Along similar lines, Aghion et al. (2015) argue theoretically and empirically that protectionist policies can be productivity-enhancing when they are targeted at sectors that are already competitive, or when they are designed to encourage competition. They present evidence from Chinese manufacturing firms that the interaction of sector-level competition and subsidy is positive and significant. This paper contributes to this literature by providing microeconometric evidence based on rich data about the effects of tax breaks in an LIC. We are able to isolate the causal mechanisms through which the policy affects firms. This provides insights into why the policy we study was less successful than that examined by Aghion et al. (2015). One reading of our findings in the context of this literature is that we provide new evidence for why 'blunt' policies are ineffective.

The paper is organized as follows. Section 2.2 introduces a simple analytical

framework with which to organise our ideas and to derive the hypotheses that the remainder of the paper will test. Section 2.3 discusses the particular policy we study and outlines key features of the Ethiopian context. Section 2.4 introduces the data we employ, Section 2.5 specifies the empirical strategy we use to identify the causal effects of the policy, and Section 2.6 presents the results. Section 2.7 presents calculations of the cost of the policy. Section 2.8 closes the paper.

2.2 Analytical Framework

To fix ideas and clarify our hypotheses, it useful to construct a simple analytical framework. We extend that of Criscuolo et al. (2012) who focus on an expression for the cost of capital owing to Hall and Jorgenson (1967), King (1975), and Ruane (1982). They use this to study the implications of EU Regional Assistance for employment and capital utilization. We extend this approach to obtain predictions for the effects of the policy on TFP. In particular, our framework formalises the intuition that IP will lower average productivity as previously non-viable firms will enter the market. It also embodies the notion that, particularly in LICs, that there may be increasing returns to scale as increased output and competition can improve average productivity through spillovers and other agglomeration externalities.

We consider a highly stylised economy comprised of a continuum of firm specific products which are all produced using the same Leontief-type production technology differing only in their Total Factor Productivity (TFP) A_i. Thus output of firm-product i is:

$$Y_i = \begin{cases} A_i \in (0, A^+) & \text{if } K \geq \overline{K} \text{ and } L \geq \overline{L} \\ 0 & otherwise \end{cases} \tag{2.1}$$

where capital and labour are normalised such that $\int_i K\, di = \int_i L\, di = 1$. This is clearly a strong assumption but one that captures well several key features of the context we study. Firstly, it reflects that since capital is relatively scarce and (unskilled) labour is abundant that firms tend to fully utilise any machinery such that the marginal benefit of any additional labour is 0. Similarly, it reflects the idea that investment in additional machinery may be 'lumpy', and thus can be more easily conceptualised as the entry of an addtional firm-product.

A second way of viewing this assumption is that it reflects that the key production contraint is a third production technology, skilled-labour or technical-expertise, as shown in **?**. Thus, in this view each skilled worker or technician is able to supervise a given amount of unskilled labour and direct the operation of a given number of machines. Production cannot happen without them and thus TFP A_i is a reduced form of the combination of the skilled worker's ability A_i^w and the characteristics of the firm A_i^f such that $A_i = g(A_i^w, A_i^f)$. Thus, if a firm is able to hire a skilled worker then given A_i^w and A_i^f and its management they will be able to produce A_i units with the requisite labour and capital. In this interpretation we could, at the cost of some additonal complication, restate (2.1) as $Y_i = g(A_i^w, A_i^f) = A_i$ if $K \geq \overline{K},\ L \geq \overline{L},$ and $A_i^w \geq 0$

Each firm-product produced necessitates capital and wage costs of $\rho K + \psi L$, where $\rho > 0$ and $\psi > 0$ and Value Added Tax rate of $1 > \gamma > 0$. The cost of capital is given by the standard Hall and Jorgenson (1967) formulation:

$$\rho = \delta + \frac{r(1 - \theta\gamma)}{1 - \gamma}, \tag{2.2}$$

where $1 > \theta > 0$ is the depreciation allowance, $r > 0$ is the interest rate, and $1 > \delta > 0$ the depreciation rate. We also assume that output prices are perfectly inelastic, and we similarly assume perfectly inelastic supply of labour and capital.[5] We assume a competitive equilibrium in which only (weakly) profitable firm-products are produced, Thus, in equilibrium, not all firms choose to produce all, or indeed any, of their potential products, and in particular, firm-product (henceforth, firm) i is produced iff it makes weakly positive profits:

$$\Pi_i = \gamma A_i - (\rho K + \psi L) \geq 0. \tag{2.3}$$

In words, this equation simply says that the post-tax profits of firm i need to be sufficient to cover the costs of the associated labor and capital inputs. We denote the level of productivity, A_i, that satisfies this condition exactly as A^*. That is,

$$A^* = \frac{\rho K + \psi L}{\gamma} \tag{2.4}$$

[5] This is purely a simplifying assumption and is not important for our results. In particular, any price effect of an increase in output due to IP will lessen the effectiveness of the IP.

Each firm's TFP, A_i, is in turn determined by the product

$$A_i = B_i(A^+ - A^*)^\phi, \tag{2.5}$$

where $B_i > 0$ is the level of TFP of firm i that would obtain in the absence of agglomeration externalities and $\phi > 0$ implies that there are positive agglomeration externalities. It follows that total output is given by:

$$Y = \int_{A^*}^{A^+} Y_i \, di \tag{2.6}$$

and average productivity is similarly:

$$\overline{A} = \frac{1}{A^+ - A^*} \int_{A^*}^{A^+} A_i \, di. \tag{2.7}$$

For simplicity, we treat the funding for any tax reduction as being obtained from elsewhere, in the context of Ethiopia perhaps from development assistance. It follows immediately that a tax relief policy, i.e. a policy which redues τ has the following consequences:

1. Output increases:

$$\frac{\partial Y}{\partial \gamma} < 0.$$

   This follows from the substituting 2.4 into the 2.6 and differentiating under the integral.

2. If $\phi < 3$ average productivity decreases:

$$\frac{\partial \overline{A}}{\partial \gamma} > 0.$$

   If $\phi > 3$ then the spillover effect is sufficiently large that the additional agglomeration effect due to the new firms entering more than offsets the effects of their lower average productivity, and $\frac{\partial Y}{\partial \gamma} > 0$. This is a very simple statement of the notion common to many of traditional 'big push' arguments for IP: If ϕ is sufficiently large then average productivity will increase, and the policy will have had an unambiguously positive impact. Whilst, caution is necessary in drawing quantitative conclusions from such a simple model that here agglomeration externalities need to be cubic suggests that alone

they may often be insufficient unless subsidies are carefully targeted. [6]

3. Unemployment falls. This follows directly from differentiating (2.4) to show $\frac{\delta A^*}{\delta \gamma} > 0$ implying that a reduction in γ to γ' leads to a reduction in A^* to A^{**} this leads to an increase in production given by $\Delta Y = \int_{A^{**}}^{A^*} y_i \, di > 0$ implying, given (2.1), an increase in L.

4. Capital utilisation increases. This follows immediately from the argument above. It is useful to note the intimate relationship between capital utilisation and employment here. If one goes up, so does the other. Thus, an increase in capital utilisation should imply an increase in employment. On the other hand, if for some reason an increase in capital were misinvested in a low-productivity asset then we should not expect much increase in employment. We shall see that this is the case below.

The overall consequences of the policy will thus depend on the distribution of the (latent) productivities of firms in the economy, the relative importance of agglomeration externalities, and the skill with which additional capital is invested. We shall see that in the case we study, that agglomeration externalities are insufficient to offset the lower productivity of entering firms, and that capital tends to be directed towards assets that are more fungible rather than productive.

Here we ignore how the tax breaks are financed. This is reasonable if they are paid for by cuts to non-productive expenditure elsewhere, from additional foreign aid, or deficit spending. The generalisation to a general equilibrium model, where the policy must be financed from other taxation, or cuts in productive government expenditure in the tradition of Barro (1990) produces the same qualitative predictions at the cost of some additional complication.

2.3 Industrial Policy in Ethiopia

Between 1974 and 1991, Ethiopia endured decades of drought, war, and political instability under the communist regime known as the Derg. During this era there was little industrial production and private enterprise was discouraged. This changed in 1994 with the promulgation of a new constitution. Since then, Ethiopia has been following an industrial development strategy named

[6] To see this, substitute (2.3) and (2.5) into (2.7) and solve for ϕ such that $\frac{\partial \overline{A}}{\partial \gamma} = 0$.

Agricultural Development Led Industrialization (ADLI). It focusses on improving agricultural productivity to both release labour for the industrial sector and increase agricultural incomes to serve as a strong market for the industrial sector's products. The overall strategy has so far comprised three five-year plans since 2000. The first plan was called the Sustainable Development and Poverty Reduction Plan (SDPRP) and began in 2000.[7] The subject of this paper is specific aspects of the SDPRP to enhance private sector development. Specifically, in 2002, the government announced a revised schedule of incentives and tax breaks. The strategy was explicitly designed to encourage manufacturing sectors that were labour intensive and that utilised Ethiopian agricultural products (see, Ministry of Finance and Economic Development, 2002). Firms were eligible for tax breaks as follows:

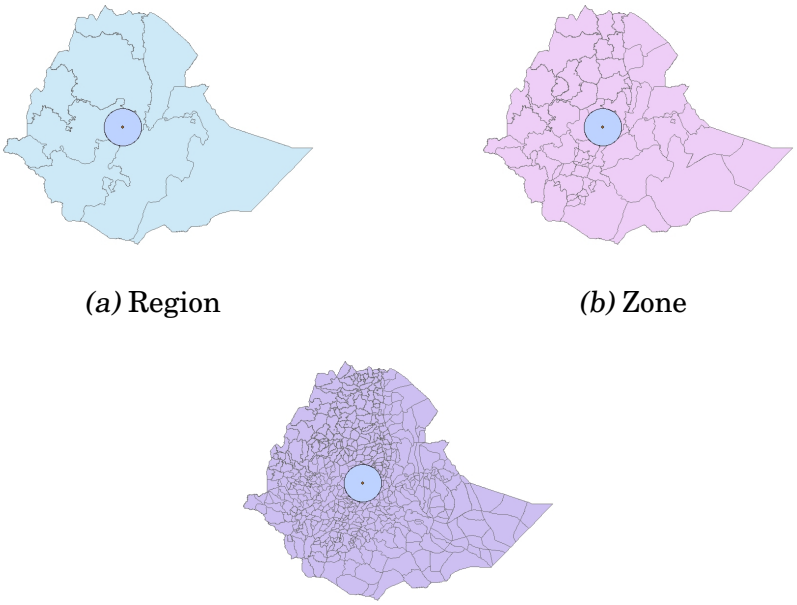
- If a firm exports > 50 percent or more or supplies > 75 percent to an exporter it received 4 years income tax exemption.
- Exports < 50 percent it received 2 years income tax exemption.
- Companies not around Addis Ababa gained 1 additional year of tax exemption.
- All enterprises were eligible to customs duty exemption on capital goods.

These investment incentives do not differentiate between specific industries. They do, however, differentiate firms based on location and export volume. The number of firms with such export volume is small and these firms are almost exclusively long standing and government owned. Instead, we focus our attention on the eligibility of firms more than 100km outside the centre of Addis Ababa for an additional tax break. Ethiopia is divided in 9 administrative regions. This division is based on ethnicity. These regions are further divided into 68 administrative zones which are in turn divided into 560 *woredas* (districts). Figure 2.1 plots these different regions and a central circle depicts the 100km zone that defines our treatment. This shows that even though Addis Ababa is the key locus of economic activity, this area is small given the size of the country. When we come to test for agglomeration externalities, we will treat zones as our unit of analysis.

In addition to these general investment incentives, and in line with the

[7] The second five year plan is called the Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) and ran for the next five years. The final phase, the Growth and Transformation Plan (GTP) finished in 2015.

Fig. 2.1: Ethiopia: Administrative Divisions



(a) Region

(b) Zone

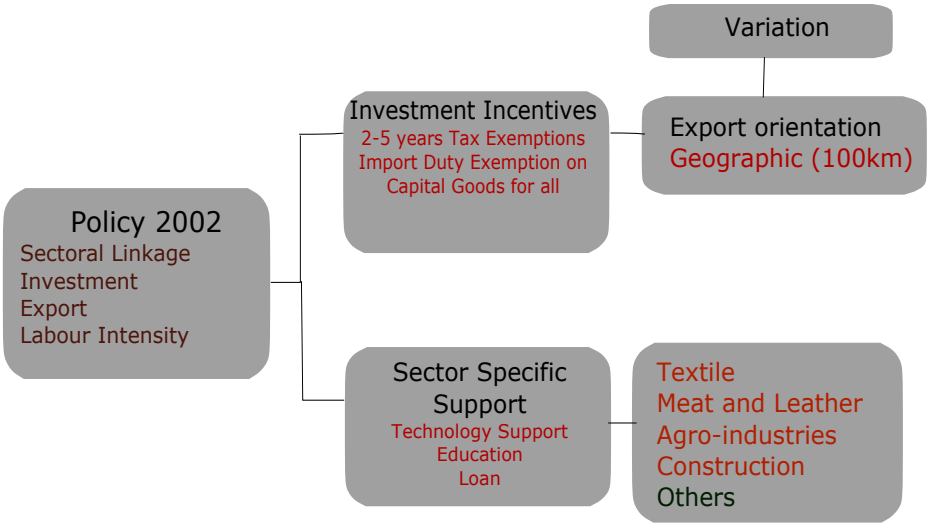
(c) Woredas

development plans discussed above, specific sectors were targeted for direct support. The selection of these sectors is mainly based on their linkages to the agricultural sector, labour intensity and export potential. These sectors are: textiles and garments; meat and leather products; agro processing; and construction. The details of this support are described in the Section A.0.3 of the appendix. The structure of the policy and support offered is outlined in Figure 2.2. Treated sectors had access to concessionary loans, as well as initiatives to improve the supply of trained workers and other technology support. Our treatment is the intersection of the two arms of the policy – being outside Addis Ababa and in a supported sector. By focusing on those firms that have received the most support we are giving the policy the best chance of being successful. That some of the sector-specific support is specifically designed to boost productivity, and thus likely to offset the predictions of declining productivity outlined in Section 2.2, improves these chances further.

2.3.1 Identification

So that estimates of the policy's effectiveness are not biased upwards, we need to be sure that the policy was not targeted at firms most likely to benefit from

Fig. 2.2: Ethiopian Industrial Policy



it. Similarly, to avoid the concern of Rodrik (2009) that estimates may be biased downwards because aid goes to firms that most need it, we must be sure that the policy was also not targeted on this basis. Inspection of the policy proclamation (Ministry of Finance and Economic Development (2002)) shows that the overall objective of these measures is clear: it is to increase the linkages between agriculture and industry; to increase employment, and to increase exports. Thus, the sectors targeted were chosen solely on the basis of whether they make use of Ethiopian agricultural produce, or are labour intensive. It is clear that all of the targeted sectors; Meat and Leather, Textiles, Agro Business, and Construction fit this description. Importantly, none of them involves a product where Ethiopia may be expected to have a particular competitive advantage (or disadvantage). Thus, whilst the government must be keen to boost productivity there is no evidence that the choice of targeted sectors was made on the basis of maximizing TFP growth.[8] Indeed, such a strategy of 'picking winners' is always fraught with difficulty, and particularly so given the context of Ethiopia at the turn of the century. Moreover, the reverse strategy of supporting losers is not consistent with the Ethiopian political context, or affordable given its budget constraints.

Inspection of a map of the region around Addis Ababa shows that the 100km

[8] There is also no evidence that these sectors were chosen for political economy reasons, and we have no evidence that there was systematic corruption in the delivery of the policy.

threshold is outside of the city and of no obvious geographical importance – it clearly reflects the usual preference for round numbers than any particular economic or geographic reality.[9] There are also relatively few firms near the threshold that might be expected to relocate. Secondly, property rights are technically all held by the Government in Ethiopia and thus the opportunity of firms to relocate is extremely limited. Thus, there is no reason to suspect that the choice of threshold geographic threshold was endogenous. Finally, one might be concerned that the firms subject to the geographic treatment are systematically different. There is little reason to believe this to be the case as most firms are engaged in low value added production using homogenous agricultural produce as inputs. Moreover, we include firm fixed effects and in the Appendix show that our results are robust to controlling for region-specific time trends. Thus, we can be clear that both arms of the policy and their intersection are exogenous.

2.4 Data

The data used in this study were obtained from the Ethiopian Large and Medium Scale Manufacturing Enterprises Census that is conducted annually by the Central Statistics Agency of Ethiopia. It contains the universe, and is hence an unbalanced panel, of firms for 14 years from 1996-2010. Initially, there are close to 600 firms in 1996. By 2010, there are around 1900. The firms are categorised into 54 industrial classification (ISIC) codes. Table .7 in the appendix reports the average number of firms in each category over the period.

As well as being available for all firms, the data are extremely rich, containing detailed information on both the establishment and ownership details of each firm. We make use of much of this information, and summarise the information we use below:

- **Ownership:** Gender of the proprietors, and the proportion of a firm's capital in public, private, or foreign ownership.
- **Establishment:** Detailed information on the month and year of establishment as well as a firm's initial capital are available.
- **Employment:** Classified by gender, salary group and occupation on a quarterly basis. Information on wages and other benefits for workers is

[9] Indeed, our results are robust to the use of an 80km or 100km threshold.

also included.

- **Products:** Data are on up to 12 products. This includes the unit price, beginning stock, production quantity and production value, and we use these data to construct our output index and productivity measures. Data on sales and exports are also available at the product level.
- **Investments:** A firm's assets are aggregated into different categories such as fixed assets, furniture, machinery and vehicles. The levels of each are detailed with the beginning stock, annual changes and ending stock.
- **Intermediate inputs:** These are at the level of the firm rather than the product. They include unit price, quantity, value, source (local versus imported) of the input.
- **Expenses:** Production expenses, such as utilities, energy, and tax, are available at the firm level.

Importantly, as discussed below, these data contain detailed information about both quantities of products produced and the quantities of the inputs used to do so. This, unusual level of detail allows us to understand precisely how the policy affected treated firms. Table 2.2 provides the usual summary of our key variables. In the rightmost column, to provide additional intuition about the complexity, scale, and nature of the manufacturing firms we study, we also describe a particular firm chosen to be representative of the median Ethiopian manufacturing firm.

We can see that the average firm employs 140 people, the median firm 113. Yet, the level of output is high compared to both the amount of capital mean, $\$0.48$ Million (22 Million Br), median firm $\$0.44$ Million and even more so compared to the book value of the machinery used which on average is only $\$0.19$ Million, and $\$77,000$ in the median firm. This, along with the high ratio of the Value of Output to the cost of the intermediate inputs, reflects the labour-intensive nature of production. Of the $\$4,000$ capital per worker only around one tenth of that is in machinery, with the rest being inventories of (cheap) raw materials. These small amounts of capital are perhaps more surprising given that these are not small firms, and often they are not new – the sample firm we consider is slightly older than average at 19 years. The oldest firm is by now over a hundred years old, but firms that predate the downfall of the Derg will have been previously, and often still are, completely state owned.

Tab. 2.2: Summary Statistics

	Mean	SD	Min	Max	Median Firm
(log) One Product TFP	4.02	2.73	-6.72	14.90	4.52
Prod. Labour	71.67	214.96	0	9,103.5	72.5
Employees (FTE)	140.94	396.25	0	15,823	113.25
Paid-Up Capital $	0.48	1.18	0.0	11.0	0.44
Book Value of Machinery $	0.19	0.72	0	21.1	0.08
Competition	0.18	0.19	0.02	1	0.3
Product Diversification	0.18	0.12	0	1.5	0.42
Government Owned	0.09	0.29	0	1	0
Age	18.57	15.65	0	99	20
Total Value of Intermediate Inputs $	0.67	1.64	0	14.40	0.23
Investment in Fixed Assets $	0.21	0.836	0	21.26	0
Value of Output $	1.84	4.41	0	40.1	1.52

Monetary quantities in millions of USD*Competition* and *Diversification* are calculated as described in Section 2.6. *Production Labour* is labour directly involved in production, as measured using temporary production workers (who account for almost all employment in our data). *Government Owned* is a dummy for government ownership.

2.5 Methodology

A key feature of the Ethiopian economy in the period we study is its rapid growth and even more rapid inflation. This dynamic environment is a useful laboratory for studying IP, but also necessitates particular care in the estimation of firm productivities. De Loecker (2011) emphasised that using data on (deflated) sales rather than production quantities could lead to bias if errors in the assumed prices were correlated with the choice of inputs. Fortunately, we are able to avoid these concerns as we use data describing both input and output quantities (and prices).

De Loecker et al. (2016) draws attention to two further sources of bias. Firstly, *"bias stemming from the unobserved allocation of inputs across products within multi-product firms"*; and secondly unobserved quality differentiation in inputs. They address the first by focusing on single-product firms thus removing the potential for bias. They address the second by deriving a control function for input prices which is incorporated directly into the productivity regressions.

We are able to address the first concern by similarly restricting our sample to single-product firms, although we do so only to demonstrate that the policy had significant negative effects on these firms. To preserve sample size, and because we are interested in all of the firms treated by the policy – we give the policy the benefit of focusing on analysing the whole sample. The second source of bias is alleviated as we use directly observed input quantities. Moreover, we also observe the full details of firms' initial capital (and its composition) and subsequent investment decisions. Thus, we may be confident – particularly for single product firms – that our results are not driven by unobserved price variation.

The dynamic nature of the Ethiopian economy during the period at hand means that the concerns about simultaneity and selection, emphasised by Olley and Pakes (1996) (OP), are of particular concern. Whilst the importance of selection means that the OP estimator is to be preferred our results are robust to using a variety of alternatives. Firstly, all of our results are robust to alternative measures of output based on a value index, in which sales are deflated by regional CPI trends to (try to) capture variations in inflation. Secondly, while we focus on firms' best selling products, we also obtain similar results using Laspeyres indices for the four or eight best sellers.

The production function estimation results are presented in Table 2.3. The preferred estimates in column 1 show a near constant returns to scale production function. Perhaps surprising is that Ethiopian firms, although labour intensive, have a lower marginal product of capital than of labour with the marginal product of labour being 0.53 in the preferred specification compared to 0.27 for capital. But, this is consistent with the literature.[10] The estimator of Levinsohn and Petrin (2003) does not allow for selection but may perform better if investment is often zero. We report results using this alternative estimator, as well as GMM and fixed effects estimators.

The effect of the policy can be recovered by regressing our productivity estimates on dummy variables describing the two arms of the policy described in Figure 2.2, and their interaction. We augment this regression with firm fixed effects, and a vector of time-varying controls. Thus, our benchmark specification is:

$$y_{ijt} = \tau_0 d_t + \tau_1 (d_i \cdot d_t) + \tau_2 (d_j \cdot d_t) + \tau_3 (d_i \cdot d_j \cdot d_t) + \beta \mathbf{X_{ijt}} + \mu_{ij} + \epsilon_{ijt}, \tag{2.8}$$

where y_{it} represents TFP and later will alternatively be employment, investment and product diversification. d_t captures the introduction of the policy and is defined as $d_t = \mathbf{1}[year \geq 2002]$. The sectoral treatment is captured with $d_i = \mathbf{1}[s \in$ *Agro industry, Construction, Meat and Leather, Textiles*$]$. The geographic treatment is given by $d_j = \mathbf{1}[$*distance* $\geq 100]$. $\mathbf{X_{it}}$ is a vector of controls discussed below. Note that we cannot disentangle the average effect of sector and location d_i and d_j from the firm fixed effects. Thus, the coefficients of interest are the difference in difference estimates: τ_1, τ_3, and particularly the double treatment estimate: τ_3. If, as indicated in Section 2.3 the policy has been successful we expect positive and significant coefficients. Following Bertrand et al. (2004) our standard errors are clustered by firm.

[10] We might expect the low levels of capital in Ethiopian firms to lead to high marginal products. But, De Loecker et al. (2016) obtain similar results for Indian firms at the product level. Firm level estimates by Bigsten et al. (2004) obtained similar results for Kenya, Ghana, Cameroon and Zimbabwe. Siba et al. (2012) also studies Ethiopian firms, and finds the marginal product of capital to be below 10 percent.

Tab. 2.3: Production Function Estimates

	(1) Olley - Pakes	(2) Levin-sohn - Petrin	(3) GMM	(4) FE
(log) Total Book Capital	0.27^{**}	0.09^{**}	0.11^{***}	0.09^{***}
	(0.12)	(0.04)	(0.04)	(0.02)
(log) Prod. Employment	0.28^{***}	0.15^{***}	0.26^{***}	0.32^{***}
	(0.05)	(0.02)	(0.06)	(0.04)
(log) Value of Inputs	0.53^{***}	0.53^{***}	0.30^{***}	0.21^{***}
	(0.02)	(0.15)	(0.03)	(0.02)
N	6534	6478	6895	11753

Column-1 Olley-Pakes presents the estimates obtained using the Olley and Pakes (1996) estimator and the single largest product quantity index. Column 2 reports the results of the Levinsohn and Petrin (2003) estimator, Column 3 an Arellano and Bond (1991) type GMM estimator, and Column 4 a simple Fixed Effects estimator. Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

2.6 Results

This section begins by showing that the empirical evidence supports the central prediction of the analytical framework outlined in Section 2.2 – that there should be no productivity improvement associated with the policy. We then demonstrate the reasons for this result. We begin by showing the effects of how the entry of new firms lowered average productivity, and moreover, that these additional firms failed only generated limited agglomeration externalities. We then show the other ways in which the policy altered (existing) firms' behaviour shedding light on why we find no positive effect on existing firms. We see that the policy led to additional diversification in existing firms, also lowering productivity. Given the tax breaks and subsidised loans available to firms are designed to reduce the cost of capital and facilitate investment, we drill down in to the form of the additional capital investments caused by the policy. These were in stores of value rather than productive machinery and we relate that to the volatile economic environment faced by firms. In doing so we note that the policy is also unsuccessful if success were defined in terms of employment or capital growth as in Busso et al. (2013) or Gobillon et al. (2012).

2.6.1 Effects on Productivity

We begin by considering the overall impact of the policy. We estimate Equation (2.8) with TFP as the dependent variable. X_{it} includes each firm's age; whether it government owned; (log) investment; product diversification; and competition following Aghion et al. (2015). We measure both competition and diversification using Herfindahl Hirschman indices. Let p_{itj} denote the share of product j of the output of firm i in year t. Then, Diversification is calculated at the firm level as $Divers_{it} = \sum_j p_{itj}^2$. Industry level competition is calculated using firms' shares of industry output o_{its}: $Compet_{ts} = \sum_i o_{its}^2$.

It is conventional to present specifications that are as demanding as possible in order to emphasise the robustness of the results. Here, we present specifications that are clearly as flattering to the policy as possible to make it clear that the lack of any evidence for a positive effect of the policy is not due to the choice of estimation strategy. In particular we include a simple post-treatment dummy rather than time trend, or region specific trends, although doing so does not alter

our results. Similarly, errors are clustered only at the firm level, although results are robust to clustering by district and year, etc. Most importantly, we focus much of our analysis on existing firms. As we will show, and as expected, new firms are (substantially) less productive than firms that predate the treatment. But, it might be argued that, in the Ethiopian context or generally, boosting the productivity of existing firms is sufficiently important to make the the proliferation of lower productivity firms unimportant. By focusing our attention on existing firms we take this form of argument seriously and by doing so rule out that the policy was successful for this (or other) subgroups.

The results are presented in column 1 of Table 2.4. We see that there is no overall effect of the policy as the coefficient on the interaction of the two arms of the policy τ_3 is negative, small, and imprecise. Both τ_2, the effect of the sectoral support policies, and τ_1, the effect of the geographically determined tax break, while positive, are also close to zero and imprecise. That the coefficients on both arms of the policy are negative is a finding that we see consistently across the different specifications reported (excluding column 5). Similarly consistent is the finding that the coefficient on the interaction is positive. This is as would be expected as additional policies to lower the costs of capital presumably have diminishing effects. The combined impact of the policy is negative ($\tau_1 + \tau_2 + \tau_3 = -0.03$ and insignificant. Column 3 reports results considering only single-product firms *à la* De Loecker et al. (2016). Now, the magnitude of the negative coefficients on the two arms of the policy are larger, but still insignificant. The interaction term τ_3 is also larger but insignificant. As is the combined effect $\tau_1 + \tau_2 + \tau_3 = -0.3$ which we cannot reject is equal to zero. To address concerns that these negative and imprecise estimates are due to the choice of productivity measure, Columns 4–6 report results for the same specification with alternative measures of TFP as the dependent variable introduced above. Column 4 reports results based on the method of Levinsohn and Petrin (2003). This method will perform better if investment is often zero in a given year.[11] Results obtained using GMM and Fixed Effects estimators are reported in Columns 5 and 6. In all but two cases the estimates of $\tau_1 - \tau_3$ are insignificant and close to zero, τ_2 is significant and negative when using the LP estimator, and significant and positive when using GMM. Thus, we may be confident that there is no evidence whatsoever that the evidence for the failure of the policy is an artefact of the choice of productivity estimator. Columns 7 and 8 of Table 2.4 address a second concern – that government owned firms may

[11] In fact, in our data investment is almost always non zero.

respond differently to the treatment. Column 7 reports results calculated using only private firms, Column 8 only government firms. In both cases, there is no effect of the policy. We also repeated this analysis for individual sectors (Table .2 in Appendix A.0.1) – the comparison is now a given treated sector compared to all untreated sectors – again there is no effect of (any part of) the policy. Table .1 shows that alternative specifications additionally including individual year effects, fixed effects for Regions or Zones, and or their interaction give similar results. Taken together, we can be confident that that the lack of an effect of the policy on TFP is robust to the choice of productivity estimators, fixed effects, government ownership, and sector. This results is also consistent with the lack of any positive effect on productivity found in more developed countries.

Other results are also in line with our expectations: firms in more competitive industries ($Compet_{ts}$ lower) are substantially more productive, although the estimate is imprecise in our preferred specification. Similarly more diversified ($Divers_{it}$ lower) firms are less productive. Given we include firm fixed effects, the coefficient on firm *age* should be interpreted as the effect on productivity of having been in business for longer. This coefficient is positive in our preferred specification, but close to zero, and not robust to other choices of estimator or output index. *Government Ownership* measures the impact, given our fixed effects, of becoming government owned. The effect is positive but sensitive to the choice of productivity estimator.

Tab. 2.4: The Effects of the Policy on Total Factor Productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OP	New Firms	Single - Product Firms	Levin-sohn - Petrin	GMM	FE	Private Firms	Government Firms
τ_0: Post-2002	-0.04		1.08***	0.28***	-0.03	0.08**	-0.00	-0.22
	(0.10)		(0.28)	(0.04)	(0.02)	(0.03)	(0.11)	(0.21)
τ_1: Sectoral Treatment	0.09		-0.13	-0.01	-0.05	-0.03	0.15	-0.06
	(0.13)		(0.37)	(0.05)	(0.03)	(0.04)	(0.15)	(0.26)
τ_2: Geographic Treatment	0.00		-0.43	-0.07*	0.05*	0.01	0.12	-0.39
	(0.11)		(0.38)	(0.04)	(0.03)	(0.03)	(0.12)	(0.27)
τ_3: Total Treatment	-0.12		0.26	0.03	-0.11**	-0.05	-0.23	0.24
	(0.20)		(0.64)	(0.07)	(0.05)	(0.06)	(0.23)	(0.39)
$Compet_{ts}$	-0.44		-0.70	-0.45***	-0.30***	-0.28**	-0.28	-0.84
	(0.33)		(0.79)	(0.12)	(0.11)	(0.11)	(0.42)	(0.55)
$Divers_{it}$	0.89***		0.83	1.54***	0.93***	1.27***	0.80*	0.69
	(0.33)		(0.66)	(0.20)	(0.12)	(0.18)	(0.46)	(0.54)
Age	0.00		0.01	-0.00	0.00	-0.00	0.00	0.00
	(0.00)		(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Government Ownership	0.35**		1.21**	-0.01	0.03	-0.06		
	(0.16)		(0.57)	(0.05)	(0.04)	(0.05)		
$\beta^{\Delta}_{\tau_1}$		-1.60**						
		(0.78)						
$\beta^{\Delta}_{\tau_2}$		2.27***						
		(0.67)						
$\beta^{\Delta}_{\tau_3}$		-3.20***						
		(1.01)						
N	6117	10570	1061	7034	5518	7034	4806	1264

τ_0, τ_1, τ_2 and τ_3 are the DDD coefficients defined in (2.8). $Compet_{ts}$ and $Divers_{it}$ are Herfindahl indices measuring competition and product diversification described in Section 2.6. Age reports how many years since the founding of the firm. Government Ownership is a dummy variable describing whether the firm is state owned. $\beta^{\Delta}_{\tau_3}, \beta^{\Delta}_{\tau_1}$, and $\beta^{\Delta}_{\tau_2}$ are the differences in the productivity of new firms entering due to the policy defined in (2.10). Standard errors in parentheses are clustered by firm. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Decrease in Productivity Due to Entry

The framework in Section 2.2 suggests that one consequence of a reduction in the tax rate will be to allow firms to enter the market that would have otherwise been unprofitable. If this is the case, then we might expect average TFP to fall as a consequence of the policy even if output is increasing. That is, that the effect of the policy on TFP due to variation on the extensive margin will be negative. To take this hypothesis to the data we note that an alternative estimator of (2.8) would be a pseudo-panel estimator as discussed by Verbeek (2008). Estimators of this type are most commonly applied to datasets that are a repeated cross section, and for which it is possible to identify subsets of the population with membership fixed over time – 'cohorts'. The data are then the set of averages of each variable by period and cohort observations, and a conventional estimation procedure (but with suitable corrections to the variance matrix) may be employed. Our strategy hinges on the fact that this approach will be inconsistent to the extent that there is entry by new firms. In our difference in difference framework, the excess entry of new firms in treated sectors and their impact on average productivity will be given by the difference between the pseudo-panel estimates and the firm-level estimates. More precisely, averaging (2.8) by sector and Zone, and indexing these cohorts as $c \in \{1, \ldots, C\}$ with asterisks denoting population quantities (see, Deaton, 1985) we have:

$$\overline{y}^*_{ct} = \tau_1(d^*_c \cdot d^*_t) + \tau_2(d^*_j \cdot d^*_t) + \tau_3(d^*_c \cdot d^*_j \cdot d^*_t) + \gamma d^*_t + \beta \overline{X}^*_{ct} + \mu^*_{cj} + \epsilon^*_{ct}. \tag{2.9}$$

For clarity, we rewrite this using $\mathbf{Z} = \begin{bmatrix} d_c & d_t & d_j & X_{it} & \mu_c \end{bmatrix}$ and Λ as the associated vector of coefficients. Moffitt (1993) showed that Λ can be estimated using the interaction of cohort and time dummies as instruments. This makes the requirements for the consistency of the estimator clear – if the composition of the cohorts is not fixed then this is equivalent to the exclusion assumption being violated.[12] Thus, assuming the measurement error is distributed as follows:

$$\begin{pmatrix} \overline{y}_{ct} - y^*_{ct} \\ \overline{\mathbf{Z}}_{ct} - \mathbf{Z}^*_{ct} \end{pmatrix} \sim i.i.d. \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{00} & \sigma' \\ \sigma & \Sigma \end{pmatrix} \right]$$

[12] If the productivities did not vary over time then the instrument relevance assumption would also be violated.

then, the estimator employed is:

$$\tilde{\Lambda} = (M_{zz} - \tau\hat{\Sigma})^{-1}(m_{zy} - \tau\hat{\sigma}) \tag{2.10}$$

where:

$$M_{zz} = \frac{1}{CT}\sum_{c=1}^{C}\sum_{t=1}^{T}(\overline{z}_{ct} - \overline{z}_c)(\overline{z}_{ct} - \overline{z}_c)' \tag{2.11}$$

$$m_{zy} = \frac{1}{CT}\sum_{c=1}^{C}\sum_{t=1}^{T}(\overline{z}_{ct} - \overline{z}_c)(\overline{y}_{ct} - \overline{y}_c). \tag{2.12}$$

Given our sample is relatively large, and contains the universe of manufacturing firms, it is reasonable to expect $\beta^{\Delta} = \tilde{\Lambda} - \hat{\beta} \approxeq 0$ if there were no firm entry. Thus $\beta^{\Delta} > 0$ (conversely, $\beta^{\Delta} < 0$) implies entering firms are more (less) productive than existing firms. Standard errors are obtained via the bootstrap. Column 2 of Table 2.4 presents the results and shows that the productivity impact of firm entry to be negative and significant as suggested by the theory. To see this, note that $\beta^{\Delta}_{\tau^1} + \beta^{\Delta}_{\tau^2} + \beta^{\Delta}_{\tau^3} = -2.53$, which is significant at all conventional levels. Interestingly, firms entering only due to the geographical treatment are more productive on average than other new firms. Whether, this reflects a positive effect of the policy or some other factor is unclear. Notably, a calculation of the the average impact of the geographical treatment across both treated and untreated sectors shows it to be equal to -0.75, suggesting an overall negative effect of the treatment. Note, that whilst productivity has fallen, output has increased. In the long-run, the presence of additional low-productivity firms may eventually impede growth, but the associated increase in output may be important in the short-run. However, the cost estimates presented in Section 2.7 suggest that this output increase has come at a substantial fiscal cost.

Decreases in Productivity Due to Diversification

One important way in which firms grow is through diversification (Berry, 1971). In Table 2.4 the coefficient on diversification is consistently positive, that is more diversification is associated with lower productivity. However, one reading of the model is that tax breaks will lead to additional diversification, and that this will lower productivity within existing firms. The model in Section 2.2 does not

describe multi-product firms specifically, but note that instead of a continuum of potential firms, we can imagine the specification describing one firm potentially producing a continuum of individual products.

Then, our expectation is that the IP will have induced firms to diversify, and thus that this is one way in which the policy led to lower average productivity. Column 3 reports the results of estimating a similar specification as in (2.8) except now we move our diversification measure to the LHS. We find that overall effect of the policy is negative, that is it increased diversification. Specifically, τ_2 is significant at the 10% level and τ_3 is insignificant but relatively precisely estimated. Testing the joint significance of $\sum \tau$ we are able to reject the null of no overall effect at all levels.

2.6.2 Effects on Capital

We have now seen that the policy was unsuccessful in encouraging productivity growth. We also seen that this is because as predicted by the theory, the new firms were less productive, and there were insufficient spillovers to offset this. We now consider the key mechanism by which firms were to be affected – cheaper capital. One might be contented, as governments often are in rich countries, with a policy that was at least successful in increasing capital levels and employment rates. We now see that the policy was also unsuccessful when judged on these criteria. Whilst, the provision of tax breaks and subsidised loans did indeed increase capital levels, we find that this increased capital was normally used for investments other than new machinery necessary for greater or more efficient production, but rather in buildings or vehicles. Furthermore, we show that this can be understood as a hedge against inflation and changes in market conditions given rampant inflation and a dynamic but challenging business environment. We then show, that as suggested by the theory, the lack of investment in productive assets limited employment growth due to the policy.

Direct Increases in Capital Due to Subsidies

Both our intuition, and Section 2.2 suggest that treated firms should increase investment as the policy lowers the cost of capital. Column 4 of Table 2.5 reports the results of again estimating (2.8); but, now with firms' total book capital on the

left-hand side. The results suggest that firms in the treated sectors increased their capital levels, and that those treated by both arms of the policy did by slightly more; but, the geographical component of the treatment was associated with lower than average capital accumulation. This latter finding suggests that owners of firms preferred to take additional profits rather than reinvest. This might explain the results in Column 2 of Table 2.4 – that the tax break discouraged capital accumulation. This suggests that the subsidised loan programme that was a large part of the sectoral treatment was more effective at increasing capital levels than the tax breaks. Testing the overall effect of the policy we can rule out that the policy did not increase capital levels, and thus on this basis may be judged as successful.

Increases in Capital are Not Invested in Machinery

Column 5 reports that despite the increases in Capital there were no overall effects on the Marginal Product of Capital; this is surprising as we would expect that a large increase in the capital stock should be reflected in a decrease, other things equal, in the marginal product.[13] Column 6 reports estimates with the ratio of machinery to overall capital on the left hand side and documents that the sectoral treatment, led to a decrease in this ratio. This implies that new investments occasioned by the policy were in other forms of capital such as buildings and vehicles. Why might firms prefer not to invest in additional machinery? One explanation is that whilst they are keen to benefit from the subsidised loan, especially as high inflation rates mean the real interest rate is negative, that they adopt a portfolio approach and choose to diversify their risk. By buying buildings and vehicles they are investing in assets that whilst offering a comparatively low return are weakly correlated with the profitability of their current product lines. Such a strategy makes most sense, however, if a firm is particularly uncertain about its future. One feature of the business environment for the firms we study is rapidly changing input prices and shifting demand. It also explains why the additional tax breaks reduced capital levels – entrepreneurs used them as an opportunity to reduce the share of their wealth accounted for by their business. They instead took the funds as additional profits or reinvested in vehicles, for instance. The consequences of uncertainty about the future are magnified by the

[13] This results also suggests that the policy is not encouraging growth by reallocating capital. If it were we would expect a large positive and significant coefficient here.

lack of of an effective bankruptcy procedure or a system of limited companies, meaning individuals are disinclined to take risks with borrowed capital.[14]

We take the hypothesis that the lack of productive investment is due to uncertainty to the data by calculating firm-year specific 'terms of trade' indices. Specifically, we calculate a price index for the input prices for each of the four best selling products, as well as a price index for their sales price. We define the 'terms of trade' as the ratio of the sum of these indices across the four products:

$$ToT = \frac{\sum_k SalesPriceIndex_{it}^k}{\sum_k InputPriceIndex_{it}^k} = \frac{\frac{\sum_{d=1}^4 Q_{i0}^d P_{kit}}{\sum_{k=1}^K P_{i0}^d Q_{i0}^d}}{\frac{\sum_{k=1}^K Q_{i0}^d P_{kit}}{\sum_{k=1}^K P_{i0}^d Q_{i0}^d}}. \tag{2.13}$$

We do not adjust for quantities sold of these products to avoid potential endogeneity bias due to responses in production decisions due to changes in prices or vice versa. We then estimate the following regression:

$$ln(machinery) = \beta ln(bookcapital) + \gamma ln(ToT) + \mu_i + \epsilon_{it}. \tag{2.14}$$

The results are reported in Column 7. In line with our hypothesis we find that the ratio of capital in machines, etc., to total book capital is higher when the 'terms of trade' of a particular firm are higher. This highlights the challenges in designing successful IP – this behaviour is the upshot of several interrelated features of the particular context. Firstly, the high-growth high-inflation environment means that firms will seek to avoid holding cash whilst being willing to incur debt. Second, entrepreneurs will be more risk-averse due to the lack of effective bankruptcy protection. Finally, the absence of a well-developed financial services sector means that firms are unable to diversify, through acquisition, for example; thus, we get the accumulation of unproductive capital. However, these three factors are not unique to Ethiopia and neither, therefore, are the difficulties they suggest in the encouragement of investment.

[14] As discussed by Lencho (2008), Ethiopian Law does provide a Bankruptcy procedure; but, the law has rarely been applied since 1960, and most lawyers are unfamiliar with it.

Tab. 2.5: Why Did the Policy have no effect?

	(1) TFP	(2) TFP	(3) Divers	(4) Book Capital	(5) MPK	(6) $\frac{Machinery}{Capital}$	(7) Machinery	(8) Prod. Labour
Number of treated firms in Zone (Standardized)	0.13*	0.11						
	(0.07)	(0.09)						
$Compet_{ts}$	0.56	0.36		-0.45**	-0.45**	0.09***		-0.10
	(0.51)	(0.61)		(0.22)	(0.22)	(0.02)		(0.09)
$Divers_{it}$	1.31**	1.31***						
	(0.50)	(0.43)						
Age	0.01	0.01	-0.00	-0.00	-0.00	0.00		0.00
	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)		(0.00)
τ_0: Post-2002			0.02***	0.46***	0.46***	-0.17***		0.16***
			(0.01)	(0.07)	(0.07)	(0.01)		(0.03)
τ_1: Sectoral Treatment			0.00	0.22**	0.22**	-0.05***		-0.03
			(0.01)	(0.10)	(0.10)	(0.01)		(0.04)
τ_2: Geographic Treatment			-0.01*	-0.27***	-0.27***	0.07***		-0.08***
			(0.01)	(0.08)	(0.08)	(0.01)		(0.03)
τ_3: Total Treatment			-0.02	0.28*	0.28*	-0.06***		0.09
			(0.01)	(0.15)	(0.15)	(0.02)		(0.06)
Government Ownership			-0.02	-0.96***	-0.96***	-0.01		0.48***
			(0.01)	(0.15)	(0.15)	(0.02)		(0.06)
(log) Prod. Labour				0.30***	0.30***			
				(0.03)	(0.03)			
(log) Total Book Capital							0.88***	0.05***
							(0.02)	(0.01)
(log) Terms of Trade							0.00**	
							(0.00)	
N	1664	980	7235	12980	12980	12788	8653	12980

Machinery is equipment directly used in the manufacturing process. Prod. Labour are workers directly involved in the production process. Terms of Trade is the ratio of firms sales price index to input price index as defined in (2.13). All other details are as for Table 2.4.

2.6.3 Effects on Employment

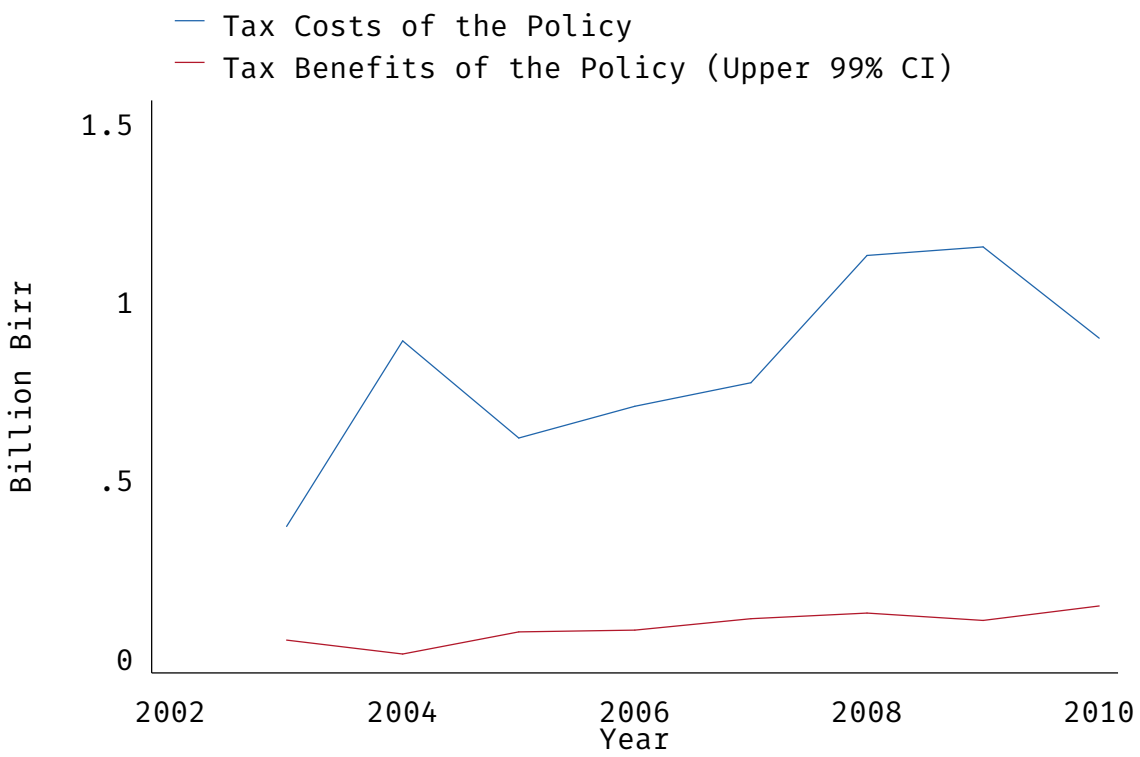
The final outcome variable we consider is employment. The theoretical framework discussed above suggests that the firm-level effects of the IP on employment will depend on the relative magnitudes of the substitution and scale effects. Column 8 of Table 2.5 shows that there was no overall effect of the policy on employment. Again, we observe a negative effect of the geographical treatment, whether this reflects the failure of the tax breaks to lead to additional capital accumulation is unclear. But, the positive and significant coefficient on (log) Total Book Capital suggests that this may be the case.

2.7 The Cost of the Policy

Rigorous policy evaluation techniques are by now routinely applied to assessing the effectiveness of different forms of aid at both a macroeconomic level, and also at the level of individual policies. Many development agencies and charities are committed to funding projects only based on evidence that they represent value for money. This suggests that IP should be evaluated on a similar benefit–cost basis. Given that we find little evidence of any positive effects of the policy, we could assume the policy had no benefits and focus on its costs. Instead, more conservatively, we prefer to assume the policy had the maximum plausible impact – the maximum of the 99% confidence bound of each of τ_1, τ_2, τ_3. Thus, we evaluate the policy on the premise, that contrary to our results, it achieved an 83% increase in TFP. We also take into account the increase in the tax base due to additional entry of firms due to the policy. We do this by comparing the number of firms that entered in treated sectors to untreated sectors and use the difference as the number of firms caused by the policy. Again conservatively, we assume that all of the additional new firms in treated sectors are because of the policy. Following the the arguments in Section 2.2, and the results in the previous section, we assume that the least productive entrants are those induced by the policy. Thus, following the notation in Section 2.2, the profit of firm i is Π_i. Denote the set of existing firms as X and the set of additional entering firms as E benefits in year t, B_t are given by:

$$B_t = T_1^t \left\{ \sum_{i \in X} \Pi_{it} - \frac{\sum_{i \in X} \Pi_{it}}{1 + \Phi^{-1}(0.995)(\tau_1 + \tau_2 + \tau_3)} + \sum_{i \in E} \Pi_{it} \right\} \tag{2.15}$$

Fig. 2.3: The Tax Costs of the Policy



where T_1 is the tax rate for firms treated by the policy and T_0 is the tax rate without it. We take a similarly conservative approach to the costs of the policy. We focus only on the loss of tax revenue although this focus will understate the cost of the policy substantially as it ignores the costs of concessionary loans and the investment in sector specific training and technology transfer programmes. In particular, the costs of the loans will be substantial, given real interest rates were far below zero. We ignore both of these other costs as the cost of the loans will depend on future delinquency rates as well as future inflation, and there is no data on the costs of training and technology transfer. Costs are given by the loss of tax revenues on existing firms:

$$C_t = (T_0 - T_1) \sum_{i \in X} \Pi_{it}. \tag{2.16}$$

Figure 2.3 plots the lost tax receipts due to the policy – the blue line – and the additional tax due to TFP growth and firm entry – the red line –by year.

The cost ranges from $39.4 Million (358 Million Birr) to over $121 Million (1100 Million Birr). Put differently, the average cost over the period was 0.5% of GDP or 5% of total Government spending. The benefits, meanwhile, even taken at the 99% Confidence Interval, are less than 10% of the costs. Given that the manufacturing sector only accounts for 5% of Ethiopian GDP and that these numbers are very much lower bounds on the costs and upper bounds on the benefits, this is a substantial stimulus. This highlights the high-stakes nature of IP: whilst potentially transformative the costs are also substantial, both in fiscal terms, and also in terms of investments in health, education, and/or infrastructure forgone. Given this scale, it is hard to credit the lack of success of Ethiopia's development strategy to a lack of ambition or insufficient courage. Arguments to the contrary – that suggest that the push in the big push we study is insufficient – are hard to sustain. Certainly, given that we have documented the Ethiopian manufacturing sector's limited ability to absorb additional investment, spending substantially more on a bigger push premised on a belief that a larger stimulus would somehow be more easily absorbed would incarnate a substantial risk.

2.8 Conclusion

Industrial policy is ubiquitous both in more and less developed countries. But its goal in rich countries, tacitly the redirection of economic activity to poorer populations and regions, is easier to achieve than those of accelerated or sustained growth in LICs. One reason for this is that tax breaks or subsidised loans, designed to encourage investment, will encourage entry by previously non-viable firms. On the other hand agglomeration externalities, for instance, may lead to a virtuous upwards spiral. To investigate this possibility, this paper analysed the causal effects of a policy typical of modern IP in LICs. Exploiting detailed firm-level data for the universe of Ethiopian manufacturing firms, we find that the policy was ineffective in raising productivity. Any gains in productivity due to the policy were more than offset by the lower quality of entering firms.

It is often supposed that manufacturing firms in LICs are capital-starved, and thus reducing the cost of capital would see rapid improvements. This also is not the case in the context we study. We found that one key reason for this is that firms are reluctant to invest in additional machinery, preferring instead to invest in assets only likely to be indirectly productive, such as office blocks or

vehicles. This would seem partly a response to rapid and variable inflation, which might make any given investment unprofitable. The lack of effective bankruptcy protection, only informal ownership of land, and acute shortages of skilled labour are also likely to be impediments to investment. One conclusion is, therefore, that the design of better IP in the future might involve more precisely targeted policies. An alternative conclusion is that rigorous programme-evaluation of a pilot scheme may be appropriate before such a large-scale policy is introduced.

The challenges faced by policymakers in designing IP for Ethiopia and elsewhere reveal why previous, aggregate-level, studies have been largely inconclusive. The application of the approach of this paper to similar policies in other LICs, like the accumulation of knowledge for richer countries, would allow the identification of what makes for successful IP in LICs more generally, and which aspects of the policy's failure are particular to Ethiopia.

3. WHY IS CAPITAL NOT PRODUCTIVE IN DEVELOPING COUNTRIES? NEW FIRM LEVEL EVIDENCE

3.1 Introduction

Despite substantial differences in average capital per worker, the marginal product of capital (MPK) is remarkably consistent across countries (Caselli and Feyrer, 2007). On the other hand there is substantial variation in the MPK within countries. This paper addresses two questions. Why is the MPK not higher in low income countries (LICs)? And, why does it varies so considerably within them? The premise of the paper is that there are at least three necessary conditions for capital to be productive. First, the use of capital equipment needs to be led or supervised by skilled workers. Second, that this equipment normally requires electricity. Third, that the goods produced must be transported economically to customers. We should not be suprised if firms can make little use of additional capital if they cannot operate or power any machine they may purchase, nor reliably sell whatever products they do make.

We study the impact of these *constraints* on manufacturing firms in Ethiopia. In common with many of the poorest countries Ethiopia suffers from frequent power outages, a comparatively limited road network, and a shortage of skilled workers in key areas. To assess the causal impact of these three *constraints* on the MPK of Ethiopian firms we use an extremely rich dataset describing the population of small and medium sized Ethiopian manufacturing firms. We combine this with a census of skilled workers, data on the road network, and a novel measure of power reliability based on nocturnal satelite imagery. Our estimates suggest that lacking any of these factors has a substantial impact on the usefullness of additional capital equipment. Specifically, we find that a firm able to increase its skilled workforce by 10% will raise its MPK by 9 percentage points. The effect of a similar improvement in the reliability of the electricity supply leads to an increase in the MPK of 4 percentage points. The effects of improved roads are smaller, but

still substantial, at around 0.3 percentage points. One interpretation of this is that improvements in the supply of skilled workers and electricity would lead, in equilibrium, to large increases in levels of capital per worker and output

This paper therefore contributes to two important literatures. The first is the literature on the Lucas (1990) paradox. This paradox points out that in spite of the shortage and implied high marginal productivity of capital in poor countries it has low level of flow from rich to poor countries. Reviewed in more detail in the next section, one reading of this literature is that it represents has sought to understand how production functions need to be modified to understand the lack of higher returns in poorer countries. For example, recent attempts to explain this paradox are related to institutional and infrastructure underdevelopment. Some cross country studies have tested these revealing that institutions and infrastructure development positively contributes to enhance productivity of capital, thus explaining the gap (Alfaro et al., 2008, Azemar and Desbordes, 2013). These studies, however, study the issue from a macro-level which does not allow for differences in technology, distortion and misallocation differences among firms within industries that would afffect the productivity of capital.

It also contributes to a second literature that studies within country and industry differences in the technology of production, see (Hsieh and Klenow, 2007) and (Montiel, 2006). One of the advantages of firm level analysis is the relaxing of the assumption of shared technology pointed out by Montiel (2006). Furthermore the scale of production in low income countries could lower the productivity of capital as hypothesised by Montiel. Shining light on these would benefit from a micro-level analysis of marginal productivity of capital. Another advantage of the micro level analysis would be to account for the differences in TFP and marginal productivity of capital caused by distortion and misallocation. This is further seen by Hsieh and Klenow (2007) who study the within country differences in TFP because of such distortion and/or misallocation.

We focus on the firm level assessment of productivity of capital mainly in connection with human capital development, road and power infrastructure. There is both theoretical and empirical work that relates these three factors to productivity of firms. Black and Lynch (1996) use firm level survey from the US to estimate the impact of human capital investment on productivity. They distinguish between the effect of eduction and the effect of training on productivity in the US. They augment the production function estimation with labour quality

indicators (education and training). They find that for a 10 percent increase in the average education level in the firm productivity rises by 4.9 percent. They also find that training out of job increases productivity significantly compared to on-the-job training. This micro approach helps understand the nuanced effect of different human capital investments thus would imply different policy measures. The paper however does not address possible endogeneity of human capital investment.

Holl (2006) analyses theoretically the importance (both direct and indirect) of transport infrastructure for firms. They find that transport infrastructure directly impacts firms' transport decisions. It also has indirect impacts on firms' location and spatial organization that in turn affects productivity. Improvement in transport infrastructure could lead to positive agglomeration externalities through easier information exchange and sharing of resources (Graham, 2007). In addition, transport infrastructure could also affect the structure of firms as firms enter and exit because of increased competition and reduced cost (Baldwin and Okubo, 2005). Empirically, Gibbons et al. (2012) look at the causal effects of improvements in major highways on employment and productivity of local firms. They address the endogeneity of road placement schemes by sufficiently narrowing the local employment accessibility which would render the variation in major highway improvement to be incidental to the locality. They find positive effects of road on employment at area level (not plant level) due to entry of firms. They also find a positive impact on labour productivity at plant level (not at the area level). A firm level study by Shiferaw et al. (2012) studies the effect of road infrastructure on patterns of entry and size of new firms in the manufacturing sector in Ethiopia. They address the endogeneity of road placement by controlling for observable criteria used in road placement by the government. They use food self-sufficiency, number of firms in the initial years and population to account for the criteria used in the road placement. They also use zone and district fixed effects to account for location specific fixed characteristics. They find that towns with better road network have significantly more number of entrants and survivors. They also have bigger entrants. They, however, do not look at the effects of road network on productivity. In addition their identification strategy does not address possible bias arising out of omitted variables. Although they have addressed simultaneity bias by explaining that the process of road placement is exogenous to firms, they have not accounted for other factors that affect both road placement and entry and survival.

Similar to road infrastructure the effects of power supply (mostly electricity shortage) on firm productivity is studied in a growing body of literature. Estimating the effect of supply variation (electricity shortage) is prone to two major challenges. the first challenge is availability of electricity shortage data. Secondly, Electricity shortages are endogenous to productivity (Allcott et al., 2014). Fisher-Vanden et al. (2015) study the effect of electricity shortages on productivity in China. They use electricity interruption data aggregated over regions. This would deal with firm specific rationing of power favouring the most productivity firms. In addition, to address potential endogeneity of regional productivity they use temperature as it is highly correlated with electricity demand. They find that firms avoid productivity losses by re-optimizing the use of factors through buying intermediate inputs instead of producing them. Firms do not self generate electricity as much. The use of nightlights collected from satellites as a proxy for economic growth is increasingly becoming common after Henderson et al. (2011), see for example Michalopoulos and Papaioannou (2013), Chen and Nordhaus (2011), Henderson et al. (2012). They show that nightlights closely mimic the official GDP statistics and are reliable indicators of economic growth.

In this paper we estimate the causal effect of human capital and infrastructure (Road and Power) on marginal product of capital at the firm level accounting for firm and industry specific covariates. This is the first paper that uses micro-level approaches study the relationship between human capital, infrastructure and the productivity of capital from the perspective of a developing country. More specifically we consider the universe of large and medium scale manufacturing firms in Ethiopia to estimate productivity of capital which we then combine with exogenous proxies of human capital, power and road infrastructure.

The paper is organized as follows. The next section provides a discussion of the previous literature and the different approaches to this problem. Section 3 will frame the context in which human capital, power and road networks are related to the productivity of capital by presenting a descriptive analysis. Section 4 presents data used in the study. Section 5 presents the methodology and results followed by the conclusion in Section 6.

3.2 Background

The seminal work of Lucas (1990) pointed out an inconsistency between the predictions of the Solow model, in which Hicks-Neutral technology and constant elasticity of scale production implies decreasing returns to factors and thus relatively high marginal productivity of capital in poor countries, and the observed low level of capital flows from rich to poor countries. Assuming a Cobb Douglas production function he estimated that marginal productivity in India would be 58 times that of the United States. This, according to the neoclassical theory, should lead to a significant flow of capital from the United States and other countries to India. However, the flow of capital to poor countries does not reflect the implied difference in marginal productivity of capital Lucas (1990).

Lucas argued forwards that the assumptions about the production function should be adjusted to include factors that explain the low flow of capital. Adjusting for differences in human capital reduces the difference in the marginal productivity of capital from a factor of 58 to 5. Further the external benefits of human capital could be used to explain the gap if the production function assumes the equalization of marginal productivity of capital. The other explanation he advances for the paradox could be imperfections in capital market like political risk. But, he partially discounts this as in formerly colonized countries this effect is not expected to be large (Lucas, 1990).

A subsequent literature has sought to explain this discrepancy between the expected high return to capital and low investment. Given the nature of the question it was natural for these studies to take a cross-country approach. Empirical investigations on both factors studied by Lucas and other factors including information asymmetry, openness of financial sector, capital price differentials, institutional quality, low scale of production are forwarded as explanation. Some of these explanations reflect a more fundamental idea that capital is not productive in low income countries due to a lack of other complementary factors like human capital and infrastructure. The second group of explanations asserts that although capital is productive capital market imperfections like information asymmetry, lack of openness,low institutional quality impede capital flows from rich to poor countries. We will briefly highlight on the intuition behind these explanations here. Our firm level production function estimation explained in the next section supports the first notion.

Using the differences in institutional quality to explain the paradox is quite common in the literature. The idea behind this notion is that while capital is indeed scarce in low income countries and has high marginal productivity, low institutional quality impedes capital flows by negatively affecting the efficient use of technology according to Alfaro et al. (2008). They construct a composite index from International Country Risk Guide to measure institutional quality. Another paper by Schularick and Steger (2008) uses the effect of property rights to measure institutional quality and finds that improvements in institutional quality will result in higher capital flow to developing countries. Moreover, this effect is larger when coupled with economic and social globalization which in turn has a stronger effect of increasing capital flows (Shell and Zheng, 2015). The importance of institutional quality for capital flows is confirmed even when we allow for non-linearity in the relationship according to Slesman et al. (2015). They use a threshold regression model to estimate a minimum level of institutional quality that would allow foreign capital flows to affect growth positively.

Another explanation in the capital market imperfection strand is the lack of financial openness. Reinhardt et al. (2013) study the effect of financial openness on the flow of capital. They find that accounting for financial openness closes the capital flow gap to low income countries. Using cross country data on current account capital flows with indexed capital account liberalization they find that capital account liberalization persistently and positively affects current account confirming neo-classical predictions. Yet another explanation is that marginal product of capital is actually similar in high and low income countries if we account for the value of capital (Causa et al., 2006). Most studies in using cross country data use PPP to value capital. However, capital in developing countries has a higher value owing to the low TFP in manufacturing (the so-called Balassa-Samuelson effect).

Clemens and Williamson (2000) study the cross country flow of British capital to explain the low volume of capital flowing to developing countries. They use data for 34 countries to investigate why only a quarter of British capital went to Asia and African in spite of the abundance of labour. They conclude that schooling, natural resources and demography rather than financial market imperfection are the key explanations. In addition to human capital the study suggests that countries with greater endowments of natural resource and with young and migrant populations are likely to host productive capital. Our study looks at some

of these factors from the firm and developing country perspectives.

Common to much of this work was the assumption that the marginal product of capital was indeed higher in poorer countries, if only the capital could reliably be invested there. This was, in part, because the Solow model predicts that the return on capital in countries with little of it should be very high. However, a subsequent body of work has shown this assumption not, in general, to be empirically verified. Caselli and Feyrer (2007) provide evidence that in fact the MPK is remarkably consistent across countries. On the other hand, related work shows that neither TFP or the MPK is not consistent within countries((Restuccia and Rogerson, 2008) and (Hsieh and Klenow, 2007)). This suggests that what Banerjee and Duflo (2005) term the 'aggregative' (country level) explanations discussed above fail on both counts.

Indeed, empirical evidence from firm level productivity estimates reveals a different story. Capital elasticity estimates from production function at the firm level is consistently below 0.2 according to the World Bank Enterprise Survey almost always lower than labour and material inputs (Saliola and Seker, 2011). More generally, Banerjee and Duflo (2005) surveying micro evidence which complement the macro estimates of Caselli and Feyrer (2007) argue there is no support for this central prediction of the Solow model whatsoever. Firm level analysis within a country helps to account for these valuation issues as it considers changes in MPK keeping capital valuation constant for all firms although it cannot be used to compare across countries.

3.3 Roads, Power, Human Capital and Productivity in Ethiopia

In this section we outline how we measure the three necessities for capital productivity identified in this paper Our estimates rely on geographical variation in these necessities and to elucidate this variation we begin with a brief illustration. Then we discuss the roads, electricity, and human capital networks, and how we measure them.

First, we consider a firm closer to Addis Ababa (the capital city of Ethiopia) which benefits from a relatively abundant supply of skilled labour,a dense road network and a relatively consistent supply of electricity. According to the Education Strategy Centre in Ethiopia 37 out of 58 private colleges are in Addis Ababa

along with the biggest public university (Addis Ababa University)(*List of Private Higher Education Institutions in Ethiopia*, n.d.). With less than 4 percent of the population, Addis accounts for 13 percent of the enrollment into Technical and Vocational Training (MOE, 2015). Addis also benefits from dense road network as it is the central market. All the major roads to other parts of Ethiopia radiate out from Addis which makes it easier for firms to access all markets. Similarly the city benefits from the smallest variation in power supply as can be seen in the nightlight data below in Figure 3.2. This gives firms significant advantage in utilizing their capital by allowing them to produce at full capacity or by allowing them to plan production flexibly.

Consider on the other hand a food processing firm in Adigrat, a city 865 km (estimated 15 hours drive) north of the capital Addis Ababa. The road network apart from the main road is not as dense; power interruptions are relatively more frequent and there are fewer professionals and skilled workers. The region the city is located in accounts for more than 5.8 percent of the population and accounts for 5 percent of the enrollment in technical and vocational training thus proportionally has a lower availability of skilled labour (MOE, 2015). Such a firm is more likely to be constrained from utilizing their machinery flexibly.

3.3.1 Road Network

One of the pre-requisites for private investment in manufacturing is access to markets. Improved access allows firms to flexibly plan production and effectively utilize plant capacity. Access in developing countries is heavily dependent on transport and storage costs. The expansion of roads would significantly reduce transport costs. In our data we have firms' actual expenditure on transport. This expenditure could be endogenous to productivity as factors that affect productivity of the firm could also affect expenditure on transport. We need exogenous variation in road infrastructure to estimate its effect on capital productivity. In this study we use the expansion of roads along with the land elevation as an exogenous variation.

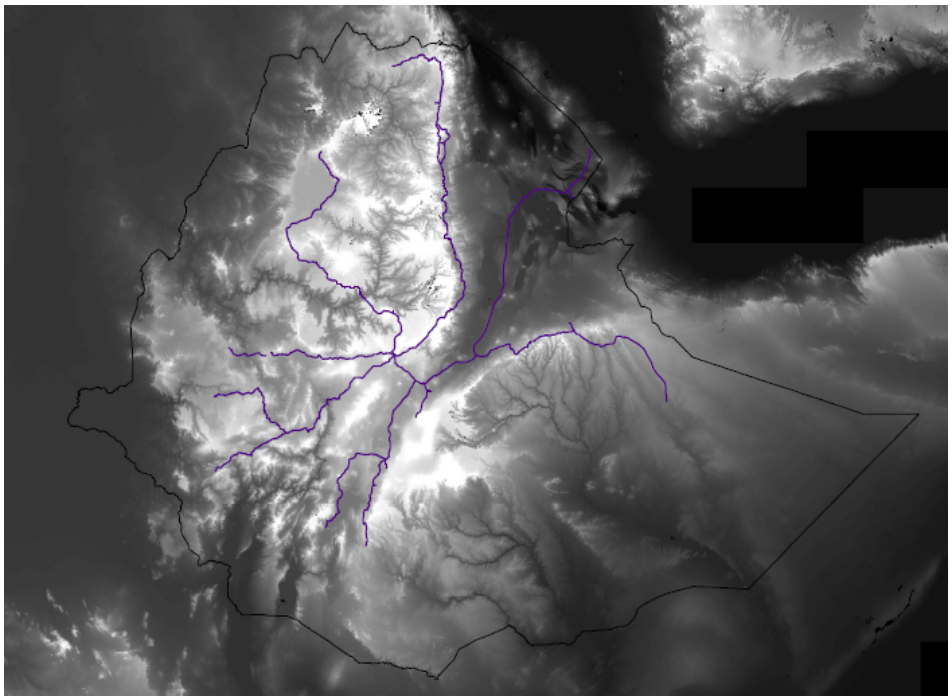
Over the past decade, there has been a sizable investment in road infrastructure in Ethiopia creating significant variation. The Ethiopian government's plan to develop the road infrastructure is set out in the Road Sector Development Programs (RSDPs) since 1997. These programs guide the priority for the selection

and implementation of road projects. These projects are supported by various donors including World Bank, EU, and ADB. As a result the road network has expanded more than four fold from 26,550km in 1997 to 110,414km in 2015. This includes expansion in both within region access roads and major trunk roads. Figure 3.1 presents the expansion of road network from 1996 to 2013 along with the elevation of land. The lighter (white) parts of the map indicate high elevation. As can be seen the western and north western parts of the country have relatively higher elevation and higher variance in elevation. These areas are also the parts of the country that are densely populated. This density also explains the more dense road network in that region as opposed to the eastern and south eastern parts of the country that have scattered population.

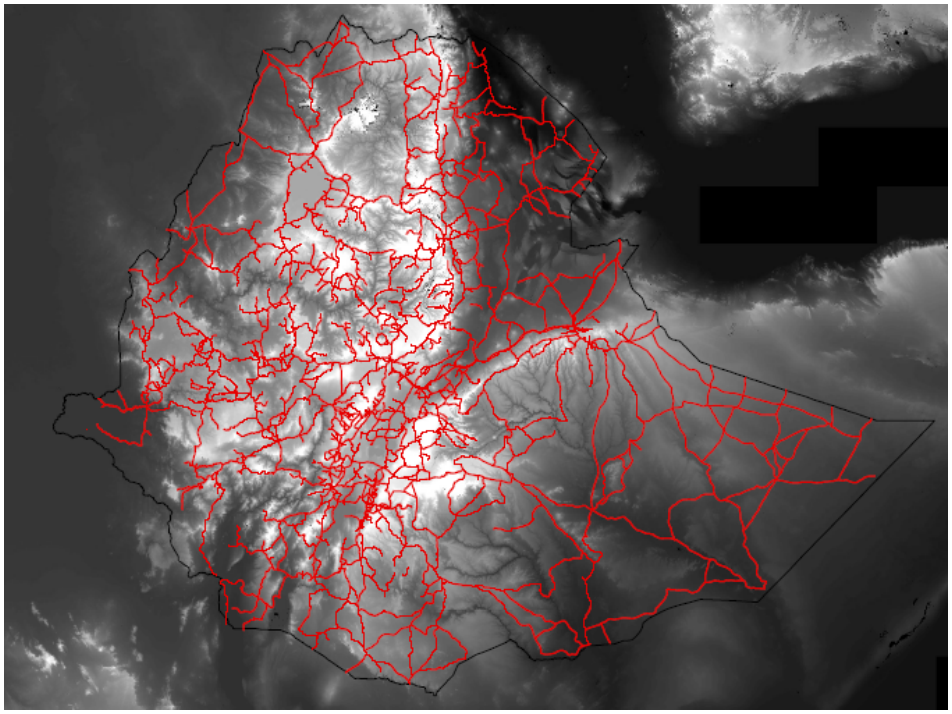
Understanding the selection procedure of road projects is essential as road placement could be endogenous to firm level productivity. Indeed the Ethiopian government considers economic potential and food production surplus along with population distribution and regional equity as criteria with which to short-list road projects proposed by regions. The short-listed projects are then subject feasibility study before final selection. The projects that are finally selected are implemented using annual action plans. A number of issues are raised by Shiferaw et al. (2012) about this procedure. The first is that it is not clear how regions select the projects they propose to the government. Furthermore, the procedure of assessing equity and economic potential is also not clear and consistent.

It is plausible that the road placements are endogenous to productivity. We assume that the decision is made on fixed zonal characteristics that we control for using zone fixed effects. In addition we use the density of roads in the zone interacted with the standard deviation of land elevation within the district as an instrument, *roadcost*. Districts with high standard deviation of land elevation are likely to spend more to transport goods as transportation takes longer in unfavourable terrain. Better and more road network would reduce the cost by more than that in a similar firm located in a district with a relatively uniform elevation. Put another way we assume that firms in mountainous areas benefit more from road construction. Constructing roads in mountainous terrain also costs more than elsewhere, and thus for a given benefit will often be deferred until cheaper, flatter, routes are built. The interaction of a pre-determined, district level, variable with a time-varying zone variable that is exogenous to the productivity of any one firm provides an exogenous time varying, district specific

Fig. 3.1: Ethiopia: Elevation and Road Network Comparing 1996 and 2013



(a) 1996



(b) 2013

instrument.

$$roadcost_{dt} = \sigma_d^{Alt} \times Dens_{zt} \tag{3.1}$$

The measure of road infrastructure variation is given by $roadcost_{dt}$ for each district and year. This is an interaction between the standard deviation of land elevation in each district given by σ_d^{Alt} and road density in the zone given by $Dens_{zt}$.

3.3.2 Power

Power supply in Ethiopia is dominated by hydro-electric power accounting for 88 percent of the total supply in 2011. In the sample period, Ethiopia was one of the fastest growing countries in the world, and a growing industrial sector led to rapidly increasing energy demand. Supply also increased significantly from 451 MW (Mega Watts) in 2002 to 2145 MW in 2014. The supply is still constrained by accessibility problems. There is need to build more and better transmission and distribution lines. This mismatch between demand and supply has caused frequent power interruptions for both households and industries.

Quantifying the power outages is challenging as data on outages are not well maintained by the power authority in Ethiopia. Manufacturing firms however, have cited that power outage is a significant obstacle to production according to the World Bank Enterprise survey in both 2011 and 2015. Out of the 1492 observations in 2011 and 2015, 90 percent of the firms reported that they faced power outages in the previous fiscal year. These firms claim that they have lost an average of 12 percent of their sales value because of power outages. This is more pronounced in the garment and furniture manufacturing firms. This is due to an average of 7.6 hours of outage at a time for an average of 11 times per month. The frequency of outage has increased from an average of 7 times per month in 2011 to more than 14 times in 2015. Outages are becoming more frequent, but remain of the same duration. Firms anticipate that there would be power outages during a month and approximately 46 percent of the manufacturing firms own or share generators. The use of generators is more prevalent among large firms. But, this is expensive, and requires a reliable source of fuel. On average firms that owned or shared generators have 150 full time permanent employees while those that do not have on average 50. This implies that smaller firms are disadvantaged by

power outage more than large firms as it is too costly for them to own or share generators. This would negatively impact on the overall productivity of small firms limiting their potential to grow. This would further stifle the overall growth of the sector. This survey illuminates the challenges posed by power outages. In order to rigorously estimate the effects of an unreliable electiricty supply we need an exogenous measure of changes in the reliability of the power supply.

To do this, we build on the literature that measures economic activity in a particular area using satelite measurement of night-time illumination (see, Henderson et al., 2012). In this study we use the annualised 'night lights' maps, collected by the Earth Observation Group*Version 4 DMSP-OLS Nighttime Lights Time Series* (n.d.). Figure 3.2 presents the brightness in night lights in 1996 and 2013. The white spots indicate the average brightness of light observed during a particular year. It can be seen that there is improvement in the provision of power as indicated by the expansion in the number of places are using electric lights. As can be seen in the figure the expansion in access is still limited compared to the increase in generation capacity. A vast majority of households still use other energy sources especially in the rural areas.

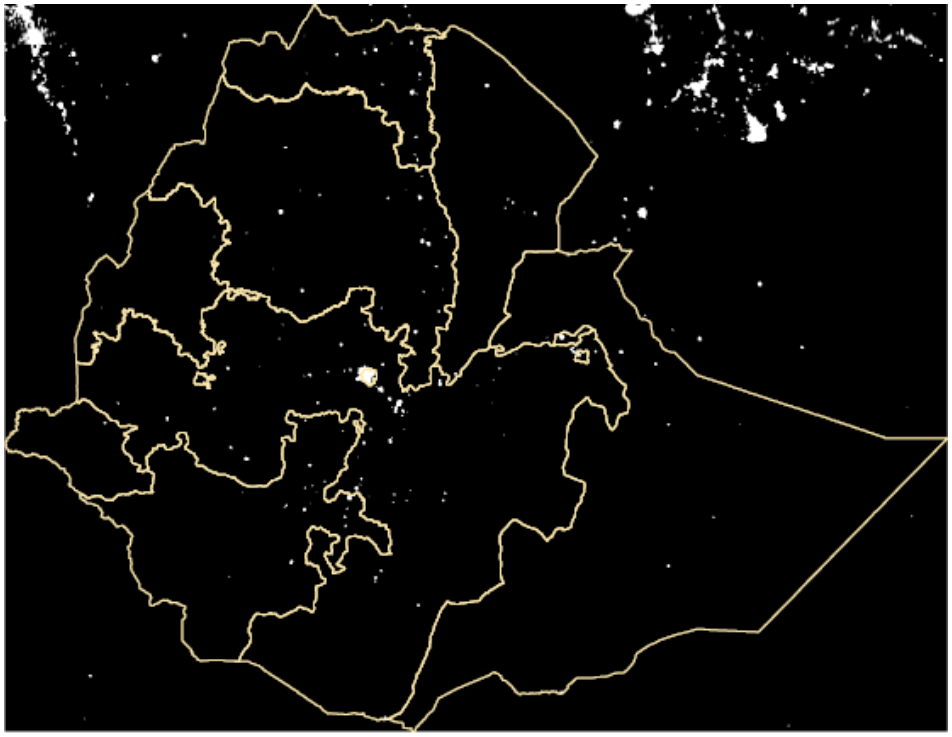
However, we are interested in measuring the reliability of the electricity supply. To calculate this we contrast two different maps, one recording the brightness in night lights adjusted for the frequency with which it was observed, and the other without the adjustment. The difference between the two may be seen in Figure 3.3. The upper panel shows the brightness in adjusted night lights while the lower one shows the unadjusted data. This difference reflects the extent of variation in the supply of power. We present a formal statement of this argument in Appendix A.0.5 The details of how we process the geographic data is presented in Appendix A.0.6.

3.3.3 Human Capital Adjustment

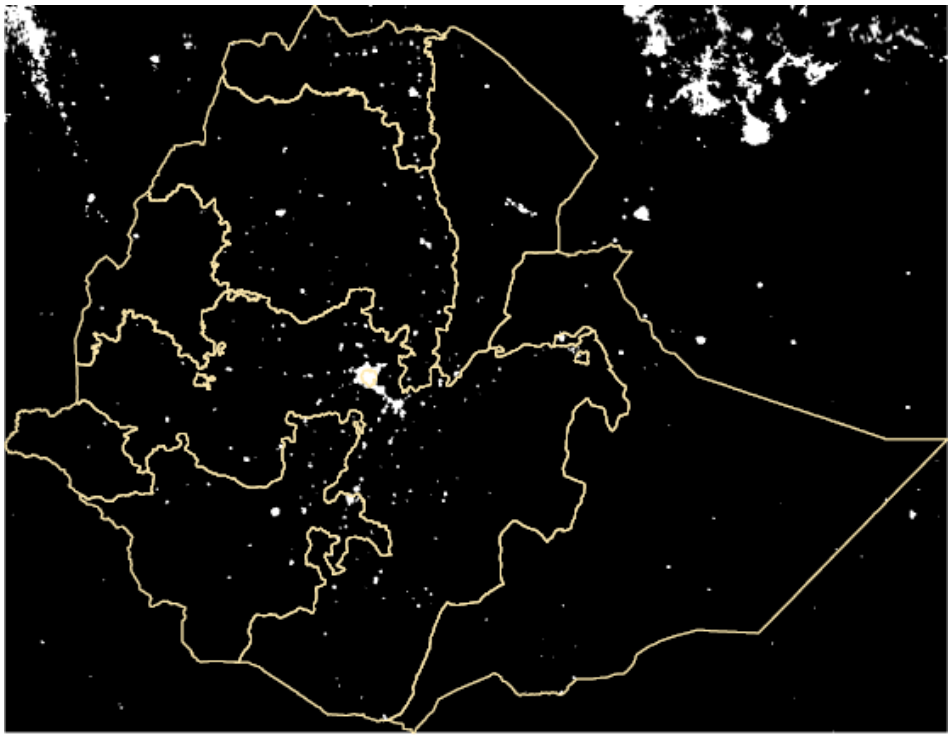
The relevance of human capital to the productivity of capital was first raised by Lucas (1990) and has extensively been discussed in the literature. Here our argument is slightly different, rather than focusing on the average level of human capital, we focus on the availability of workers with specific technical skills.[1]

[1] The detailed employment information in our data mean that we are able to incorporate human capital information in our productivity estimates.

Fig. 3.2: Ethiopia: Brightness of Night Lights Unadjusted for Frequency

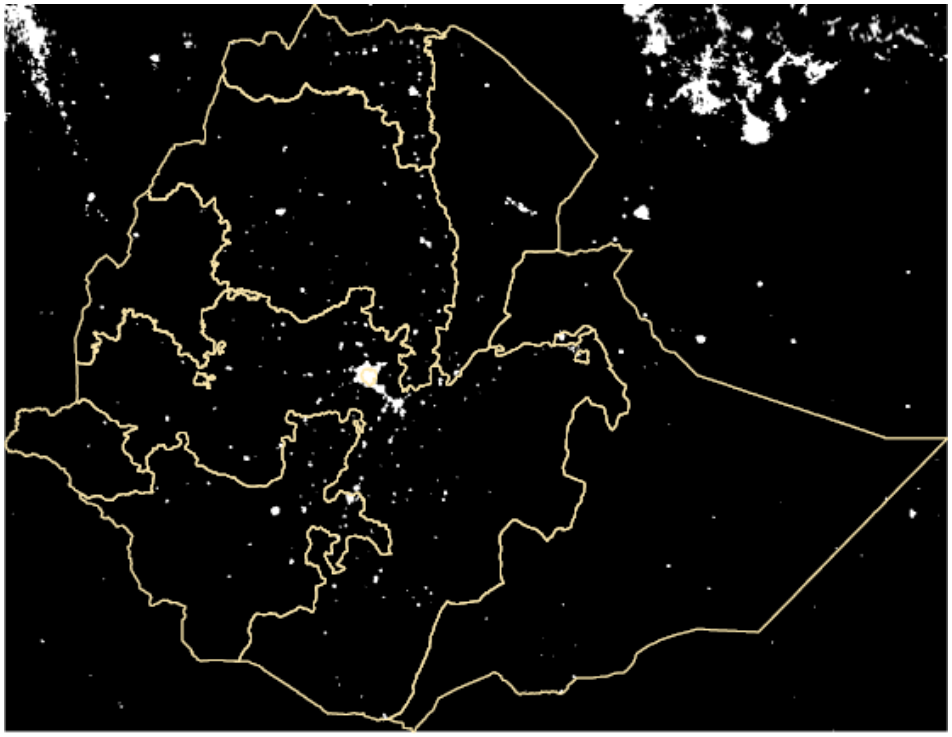


(a) 1996

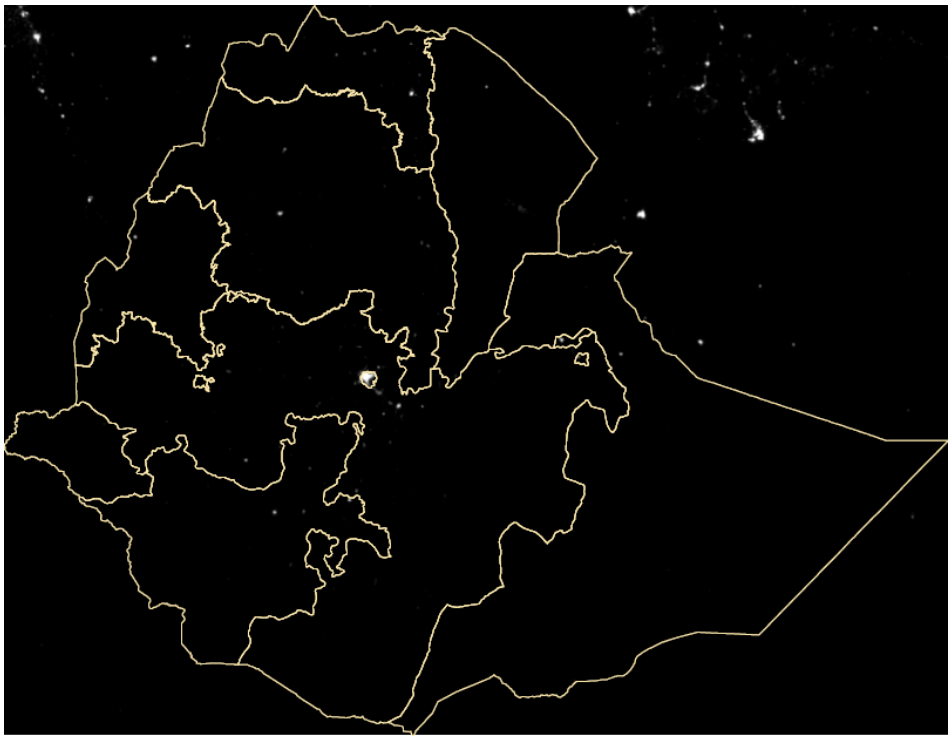


(b) 2013

Fig. 3.3: Ethiopia: Unadjusted and Adjusted Brightness of Night Lights 2013



(a) Unadjusted



(b) Adjusted

Similar to the road and power measures we explained above, it is challenging to identify the impact of human capital on capital productivity because of the endogeniety of employment decisions by firms. We therefore use the regional supply of professional labour.

The annual supply of professional labour has increased significantly over the years. We take this measure from the Urban Employment and Unemployment Survey conducted bi-annually. We have the number of professionals for a particular region for the years 2003, 2004 and 2009-2012. The average number of professionals ranges from 48,616 in 2003 to 116,506 in 2012. This is in line with the expansion of tertiary education since the early 2000s. There are, however, significant regional disparities in the distribution of professional and technical employees in the country. Addis Ababa accounts for on average 29 percent of the total number of professional and technical employees with only 5 percent of the total population. It is followed by the biggest region Oromia with the 27 percent of the total professional and technical employees with 34 percent of the total population. The number of professional and technical employees is consistent with the distribution of manufacturing firms. Close to 52 percent of the manufacturing firms are located in Addis Ababa with significantly more in the surrounding zones of the Oromia region. In line with the hypothesis that marginal productivity of capital is high in places where there are a good supply of skilled labour, Addis Ababa and Oromia regions show higher marginal productivity of capital with a high percentage of professional and technical employees. Figure 3.4 shows that the highest marginal productivity of capital in Addis Ababa and Oromia regions along with the number of professional and technical employees. This indicates the positive relationship expected between the two but cannot speak of any causal relationship. There could be a number of factors that could benefit firms by gathering around Addis Ababa and the surrounding zones in addition to access to human capital.

Our identifying assumption is that the labour market is geographically segmented. That is, workers do not move from one zone to another and hence the existence of an additional worker in a zone is unrelated to the activities of a particular firm in a different zone. It is not unreasonable to assume segmented labour market as relocation will often be prohibitively expensive especially when working for firms that are smaller in size. This is partially confirmed by Serneels (2008) who asserts that labour market segmentation is a convincing explanation for non-negative duration dependence in unemployment. We assume that the number of

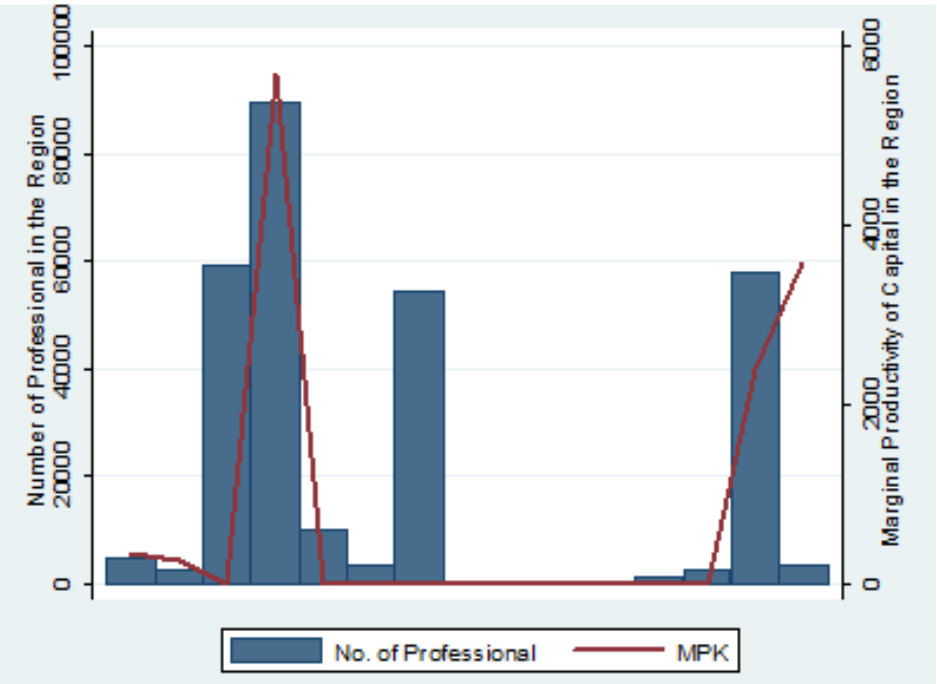


Fig. 3.4: Average Number or Professional and Technical Employees and Average MPK

professionals within a region and zone is highly correlated to the human capital availability to the firm but is exogenous to activities of one firm. One issue is that if there is a particularly large or successful firm then, as it grows larger it may be able to affect the supply and demand of professionals in the zone. We control for the size of firms in the estimations.

3.4 Data

The data set used in this study is obtained from the Ethiopian Large and Medium Scale Manufacturing Enterprises Census that is conducted annually by the Central Statistics Agency of Ethiopia. It represents an unbalanced panel of firms from 1996-2010 (a period of 14 years). The number of firms starts from close to 600 firms in 1996 and grows to around 1900 by 2010. The firms are classified into 54 industrial classification (ISIC) codes.

3.4.1 Productivity Estimation Data

The data are extremely rich and there is detailed information on both the establishment and ownership details of the firm, (such as the gender of the proprietors and capital share structure). Given the importance of the firm entry margin in our analysis detailed information on the month and year of establishment as well as firms initial capital are available. The employment data are also very detailed and are classified by gender, salary group and occupation on a quarterly basis. Wages and other benefits for workers are also included. We are also able to employ detailed data on up to twelve of the firms products including the unit price, beginning stock, production quantity and production value to construct our prices indices and to calculate our productivity measures. Data on sales and export are also available at the product level. Investment in different types of fixed assets, furniture, machinery, vehicles are detailed with the beginning stock, changes and ending stock of these assets. The data on intermediate input use are also detailed but at the level of the firm rather than product. It includes unit price, quantity, value, source (local vs imported) of the input. Other expenses like utility, energy, tax are also available at the firm level. The beginning, ending and changes of inventory is also available in the data. [2]

3.4.2 Infrastructure Data

Such detailed data contains measures of human capital and indicators of infrastructure. It contains employees at various positions and salary. We have the number of professional and technical employees along with total wages paid to them. This is a good indicator of human capital available in the firm. We have in addition firms' expenditure on power and transport which would be a good indicator of the supply of road and power to firms.

However, using these variables to explain marginal product of capital may result in biased estimates as professional employees and expenditure could be endogenously determined. To address this we use alternative indicators

[2] Given such a comprehensive list of variables, there are some missing values, necessitating some aggregation for use in the econometric analysis. Given the rapid growth rate of the Ethiopian economy in the period we study, and regular entry of firms during the period considered, the data were subject to extensive hand cleaning and matching to remove inconsistencies and mismatching of firms across time.

that we argue to be exogenous as instruments. We use regional level supply of professionals in the urban areas to measure human capital supply to the firm. This is obtained from the bi-annual Urban Employment and Unemployment Survey of the Central Statistics Agency of Ethiopia.

3.4.3 Geography Data

In addition to the firm level and employment data we use geographic data on power, road and elevation matched to the administrative zones and districts in which firms are located. We do not have exact GPS location of the firms. However the district classification is sufficiently small enough to effectively describe the attributes used in the study. We use geographic data on nightlight brightness variation to measure variance in power supply. We sum the road length within the district along with the variation in elevation to measure transportation cost. These geographic data are obtained from various GIS data repositories: GeoComm, DIVA-GIS, and Earth Observatory Group. We use detailed data pertaining to night lights (variation) to measure variation in the power supply to firms. We also use land elevation data along with road network lines to which we geographically combine with the districts where the firms are located. These are used to measure transport cost. We describe the trends and relations of these variables in the next section.

3.5 Methodology and Results

In order to estimate the relationship between marginal productivity of capital we need to have production function estimates. We discuss these estimates in the next section. Having estimated the production function we construct the marginal productivity of capital for each firm and year combination. We use this as a dependent variable to estimate what determines marginal productivity of capital. This section has two subsections the first detailing the methods used in the production function estimation taken from Gebrewolde and Rockey (2016) and the second presenting the method and results of the marginal productivity equation.

3.5.1 Productivity Estimates

The marginal productivity of capital is calculated based on TFP estimation coefficients taken from Gebrewolde and Rockey (2016). The results of the TFP estimations using the various output indices is reproduced in Table 2. The first column shows TFP estimated based on the information on the major product of the firm using the OP method. The second and third columns present the productivity estimates based on a 4 and an 8 product output index respectively using the OP method. the fourth column presents estimates based on value of total output using the Levinson-Petrin estimator which adjusts for discontinuities in investment. Columns 5 and 6 present alternative estimates based on GMM and fixed effects respectively.

In all estimations the marginal product of capital is substantially lower compared to the expected high productivity of capital in a capital scarce production environment. The 4 and 8 product indices are less reliable because of measurement problems in recoding the units and values of the non-major products of firms. All the other methods reveal that the marginal product of capital is lower than material inputs and employment ranging from 0.09-0.27. These low marginal product of capital estimates are not unique to this study as indicated in Gebrewolde and Rockey (2016) and Saliola and Seker (2011).

We will now look deeper into why the marginal product of capital is lower in spite of its scarcity. We explore the relationship between marginal product of capital and a host of complementarities that render capital to be more productive. We explore the efficacy of human capital, road infrastructure and power supply in increasing the productivity of capital. To do this we try to identify exogenous changes in the supply of these complementary variables and relate them with marginal product of capital. We expect that increased supply would result in higher productivity of capital. This would thus explain part of the deficiency in marginal product of capital.

3.5.2 What Determines the productivity of Capital?

We take two approaches to estimating the effects of human capital, road infrastructure and power on the productivity of capital. We then construct the marginal product of capital (MPK) using the coefficient of capital from the

Tab. 3.1: Production Function Estimates (Reproduced from Gebrewolde and Rockey (2016)

	(1) OP 1-Product	(2) OP 4-Products	(3) OP 8-Products	(4) Levinsohn-Petrin	(5) GMM	(6) FE
(log) Total Book Capital	0.27**	-0.01	-0.00	0.09**	0.11***	0.09***
	(0.13)	(0.07)	(0.05)	(0.04)	(0.04)	(0.02)
(log) Prod. Employment	0.28***	-0.03	-0.01	0.15***	0.26***	0.32***
	(0.06)	(0.03)	(0.03)	(0.01)	(0.06)	(0.04)
(log) Value of Inputs	0.53***	0.05***	0.03***	0.53***	0.30***	0.21***
	(0.02)	(0.01)	(0.01)	(0.15)	(0.03)	(0.02)
N	6534	5897	5971	6478	6895	11753

OP 1-Product are the estimates obtained using the Olley and Pakes (1996) estimator and the single largest product quantity index. OP 4- and OP 8- refer to the same estimator applied to the 4 and 8 product quantity indices. Column 4 reports the results of the Levinsohn and Petrin (2003) estimator, Column 5 an Arellano and Bond (1991) type GMM estimator, and Column 6 a simple Fixed Effects estimator. The last three columns all use the 1-Product Measure. Standard errors in parentheses. The last two columns report analytical standard errors clustered by firm, in the first four columns (clustered) standard errors are obtained via the Bootstrap. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

production function.

starting from;

$$Y_{it} = AK_{it}^{\beta_k} L_{it}^{\beta_l} M_{it}^{\beta_m} \tag{3.2}$$

$$\frac{\partial Y_{it}}{\partial K_{it}} = A\beta_k K_{it}^{\beta_k - 1} L_{it}^{\beta_l} M_{it}^{\beta_m} \tag{3.3}$$

and thus

$$mpk_{it} = \beta_k * (Y_{it}/K_{it}) \tag{3.4}$$

where $mpk_{it} = \frac{\partial Y_{it}}{\partial K_{it}}$.This yields the marginal productivity of capital in each firm for each year. This is used as a dependent variable. The estimated equation is as follows

$$ln(mpk_{it}) = \gamma_1 + \gamma_2 ln(\mathbf{hc}_{it}) + \gamma_3 ln(\mathbf{pwr}_{it}) + \gamma_4 ln(\mathbf{rd}_{it}) + \Gamma\mathbf{X} + \eta_{it} \tag{3.5}$$

where hc is human capital measured by the number of professionals in the region, pwr is power availability measured by variance in night lights, rd is road network within a particular district weighted by land elevation and X are other covariates. We primarily use instrumental variable regression to address endogeneity arising from firm decision to spend on transport, power and human capital. As indicated above expenditure on human capital could simultaneously be determined with productivity of capital. The same is true of transport and power cost. Other firm performance variables could also affect both productivity of capital and human capital and infrastructure. Thus, OLS estimates will suffer from omitted variable and simultaneity. Therefore to address this we need to use instrumental variables, so that we can identify the effects of exogenous variations in the explanatory variables. Accordingly, as above, we use regional supply of professionals and technical employees as an instrument to instrument for the employment of skilled technicians. As before, the actual professional employees of the firm is correlated to regional supply. We argue that the regional supply is exogenous to the activities of small firms. For transport infrastructure we use road density weighted by the standard deviation in land elevation defined in (3.1). For power we use the variance of the night light data. If the variance is high it would imply that there are frequent outages.[3] We also use the instruments as proxies in the specification

[3] One could argue that firms use power during day time and night lights may not reflect that. It is, however, reasonable to assume that the frequency of outage of night lights are reasonable estimates of the frequency of outage during the day time. Thus, whilst this may lead to reduced

which provides estimates for a larger sample.

Table 3.2 presents the instrumental variable estimation results for each factor separately. We begin by presenting OLS estimates, for each factor. The first column uses the actual expenditure on transport as an explanatory variables. The second column includes the actual wages and salaries paid to professional and technical employees by firms. The third column includes actual expenditure on electricity by firms. Similarly, more productive firms will employ more skilled staff, and benefit from more reliable power. The coefficient for the three variables is as positive and significant as expected. Columns 4 - 6 present the results of instrumental variable regression. Similar to the first three columns, each column represents one variable of interest. With exception of the instrument for transport cost, human capital and power have a positive and significant effects on the productivity of capital as expected. More specifically a 10 percent increase in human capital (total wages paid to professionals and technical employees) increases the marginal productivity of capital by 9 percentage points. The magnitude of this effect is clearer when we consider that it implies that a firm moving from 2 to 3 skilled workers, as might be typical in the data, would see a tripling of its MPK, with it increasing from the average of around 0.2 to 0.65. Given well functioning capital markets, this would implying substantial growth in the size of the firm. The weak instruments test indicate that the instruments are valid with the exception of the transport regression. We augment this with a regression by including the instrument as a proxy.

relevance of instrument it will not affect the consistency of our estimates.

Tab. 3.2: The Effect of Infrastructure and Human Capital on Capital Productivity (IV Regression)

	(1) Trans	(2) Prof	(3) Elec	(4) I(Trans)	(5) I(Prof)	(6) I(Elec)
Log(Capital)	-0.90***	-0.92***	-0.89***	-0.71***	-0.94***	-0.90***
	(0.01)	(0.01)	(0.01)	(0.19)	(0.02)	(0.01)
Log(TransExpend)	0.07***			-1.44		
	(0.01)			(1.42)		
Log(Employment)	0.69***	0.43***	0.65***	1.05***	0.20***	0.53***
	(0.05)	(0.08)	(0.08)	(0.33)	(0.07)	(0.10)
Log(ValueInputs)	0.13***	0.09***	0.11***	0.77	-0.06***	0.05*
	(0.01)	(0.02)	(0.02)	(0.58)	(0.02)	(0.03)
Log(WagesProf)		0.39***			0.91***	
		(0.04)			(0.08)	
Log(ElectricityExp)			0.17***			0.46***
			(0.03)			(0.12)
Zone Fixed Effects	Yes	Yes	Yes	No	Yes	Yes
Observations	9546	11985	8058	4310	4329	4920
Cragg-Donald F				1.84	110.05	51.85

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Trans-specification to estimate the relationship between expenditure on transport and MPK; Prof - specification to estimate the relationshio between wages paid out to professionals and MPK; Elec - specification to estimate the relationship between expenditure on electricity and MPK; I(Trans)-Instrumental variable regression results where transport is instrumented by road density and elevation; I(Prof) - Instrumental variable regression results where wages of professionals is instrumented by number of professionals in the region; I(Elec) - Instrumental variables regression results where expenditure on electricity is instrumented by the difference in adjusted and unadjusted nightlights.

Similarly, a 10 percent increase in power usage (electricity expenditure) results in 4 percentage points increase in marginal productivity of capital. This effect is also extremely large. It implies that if the average firm, according to the World Bank survey discussed above, suffers outages equivalent to around 15% of all hours in a month then eliminating this would increase the MPK in the average firm by 12 percentage points or more than 50%. Again, given access to capital, this would be expected to lead to substantial growth in the size of a firm.

There is no statistically significant effect of transport costs on productivity. Although the coefficient is large, it is also not of the expected sign.

Table 3.3 reports alternative estimates using the instruments as proxy variables. Columns 1-4 report OLS estimates analagous to those in Table 3.2. The results using proxies are in columns 5 -8. Column 5 uses difference between adjusted and unadjusted variables as a proxy for power interruption. As the difference increases it implies that the particular brightness is observed less frequently which in turn implies that there is power fluctuation in that particular region. This is expected to negatively affect the productivity of capital. Accordingly, the results indicate that as the difference in night light frequency increases by 10 percent the productivity of capital declines by 0.2 percent. This is significant at 1 percent significance level. Column 6 uses the number of professionals in the region as a proxy for the supply of human capital for the firm. The results indicate that a 10 percent increase in the number of professional and technical employees in the region leads to 5.6 percent increase in the productivity of capital. Similarly using the density of roads weighted by the elevation as a proxy for transport infrastructure (transport cost) we find that a 10 percent increase in the road density weighted by elevation results in 0.3 increase in the productivity of capital.

Tab. 3.3: The Effect of Infrastructure and Human Capital on Capital Productivity (Proxy)

	(1) Elec	(2) Prof	(3) Trans	(4) All	(5) P(Elec)	(6) P(Prof)	(7) P(Trans)	(8) P(All)
Log(Capital)	-0.89***	-0.91***	-0.90***	-0.90***	-0.90***	-0.91***	-0.91***	-0.90***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)
Log(ElectricityExp)	0.17***			0.19***				
	(0.03)			(0.04)				
Log(Employment)	0.65***	0.48***	0.69***	0.54***	0.56***	0.47***	0.52***	0.36***
	(0.07)	(0.10)	(0.05)	(0.09)	(0.10)	(0.07)	(0.09)	(0.05)
Log(ValueInputs)	0.14***	0.22***	0.15***	0.11***	0.24***	0.17***	0.24***	0.16***
	(0.02)	(0.04)	(0.02)	(0.03)	(0.05)	(0.04)	(0.04)	(0.03)
Log(AdminEmployees)		0.15***		0.08*				
		(0.05)		(0.05)				
Log(TransExpend)			0.07***	0.06***				
			(0.01)	(0.01)				
Log(Night_lights)					-0.02***			-0.02
					(0.01)			(0.01)
Log(No.Professionals)						0.56***		0.61***
						(0.12)		(0.03)
Log(Roads*Elevation)							0.03**	0.03***
							(0.01)	(0.01)
Observations	9005	11896	10337	5892	8647	5751	6644	788

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Trans-specification to estimate the relationship between expenditure on transport and MPK; Prof - specification to estimate the relationshio between wages paid out to professionals and MPK; Elec - specification to estimate the relationship between expenditure on electricity and MPK; All -Specification to estimate all the three variables of concern transport, electricity and professional. P(Trans)-Specification where road density and elevation are used as proxy for expenditure on transport; P(Prof) - Specification where regional supply of professionals is used as a proxy for wages paid to professionals; P(Elec) - Specification where the difference in adjusted and unadjusted nightlight is used as a proxy for expenditure on electricity.

To investigate the effects of road infrastructure we directly use it as an explanatory variable with regional and time fixed effects. Table 3.4 presents the results of this estimation. The results show that a 10 percent increase in the density of roads (weighted by elevation) significantly and positively affects marginal productivity of capital by an average of 0.3 percent. We also check the robustness of these estimates including regional and time fixed effects. The result is robust to time and zone fixed effects. Controlling for zone fixed effects slightly increases the effect of roads on the productivity of capital.

Tab. 3.4: The Effect of Road Infrastructure on Capital Productivity

	(1) Trans	(2) Trans	(3) Trans	(4) P(Trans)	(5) P(Trans)	(6) P(Trans)
Log(Capital)	-0.90***	-0.91***	-0.90***	-0.91***	-0.90***	-0.91***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Log(TransExpend)	0.07***	0.05***	0.07***			
	(0.01)	(0.01)	(0.01)			
Log(Employment)	0.69***	0.72***	0.69***	0.52***	0.74***	0.52***
	(0.05)	(0.05)	(0.05)	(0.09)	(0.07)	(0.08)
Log(ValueInputs)	0.15***	0.10***	0.13***	0.24***	0.10***	0.23***
	(0.02)	(0.01)	(0.01)	(0.04)	(0.02)	(0.03)
Log(Roads*Elevation)				0.03**	0.02*	0.04***
				(0.01)	(0.01)	(0.01)
Time Fixed Effects	No	Yes	No	No	Yes	No
Zone Fixed Effects	No	No	Yes	No	No	Yes
Observations	10337	10337	9546	6644	6644	6619

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Columns 1-3 - specification to estimate the relationship between expenditure on transport and MPK with varying time and zone fixed effects; Column4-6 -specification where road density and elevation is used a proxy for expenditure on transport with varying time and zone fixed effects

Table 3.5 presents a separate analysis of human capital using time and zone fixed effects. The effect of availability of human capital (measured by the number of professionals in a region)is expected to be positive. The larger the number of professional available to the firm within the region the better utilized firm's capital. This would lead to an increase in the marginal productivity of capital. The result from the proxy estimation reveals that 10 percent increase in the number of professionals in the region is related to 3 percent increase in the marginal productivity of capital. This of course would depend on the mobility of labour across regions. Although we have accounted for zone fixed effects, time varying location specific factors could affect both the availability of human capital in the region and firm productivity thus introducing bias. When we account for time fixed effects the availability of human capital in the region loses significance, perhaps due to the explanatory power of the fixed effects.

Tab. 3.5: The Effect of Human Capital on Capital Productivity

	(1) Prof	(2) Prof	(3) Prof	(4) P(Prof)	(5) P(Prof)	(6) P(Prof)
Log(Capital)	-0.91***	-0.91***	-0.91***	-0.91***	-0.90***	-0.92***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
Log(AdminEmployees)	0.15***	0.10***	0.18***			
	(0.05)	(0.03)	(0.06)			
Log(Employment)	0.48***	0.69***	0.46***	0.47***	0.69***	0.42***
	(0.10)	(0.04)	(0.10)	(0.07)	(0.05)	(0.07)
Log(ValueInputs)	0.22***	0.09***	0.20***	0.15***	0.10***	0.15***
	(0.04)	(0.01)	(0.04)	(0.03)	(0.02)	(0.03)
Log(Professionals)				0.32***	0.06	0.29***
				(0.08)	(0.04)	(0.08)
Time Fixed Effects	No	Yes	No	No	Yes	No
Zone Fixed Effects	No	No	Yes	No	No	Yes
Observations	11896	11896	10936	5751	5751	4793

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Columns 1-3 - specification to estimate the relationship between wages paid to professionals and MPK with varying time and zone fixed effects; Column4-6 -specification where regional supply of professionals is used a proxy for wages paid to professionals with varying time and zone fixed effects

For power the proxy is the difference in the adjusted and unadjusted night light presented in Section 3.3.2. We expect a negative relationship this proxy and the productivity of capital as an increase in the difference implies high fluctuation in electricity supply. More fluctuation is related to lower productivity of capital. The results indicate that a 10 percent increase in power fluctuation is related to a significant 0.2 percent reduction in productivity of capital.

Tab. 3.6: The Effect of Power on Capital Productivity

	(1) Elec	(2) Elec	(3) Elec	(4) P(Pwr)	(5) P(Pwr)	(6) P(Pwr)
Log(Capital)	-0.89***	-0.91***	-0.89***	-0.90***	-0.89***	-0.90***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Log(ElectricityExp)	0.17***	0.15***	0.17***			
	(0.03)	(0.04)	(0.03)			
Log(Employment)	0.65***	0.68***	0.65***	0.56***	0.75***	0.57***
	(0.07)	(0.08)	(0.08)	(0.10)	(0.04)	(0.09)
Log(ValueInputs)	0.14***	0.07***	0.11***	0.24***	0.11***	0.22***
	(0.02)	(0.01)	(0.02)	(0.05)	(0.01)	(0.04)
Log(Night_lights)				-0.02***	-0.01*	-0.02**
				(0.01)	(0.01)	(0.01)
Time Fixed Effects	No	Yes	No	No	Yes	No
Zone Fixed Effects	No	No	Yes	No	No	Yes
Observations	9005	9005	8058	8647	8647	8615

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Columns 1-3 - specification to estimate the relationship between expenditure on electricity and MPK with varying time and zone fixed effects; Column4-6 -specification where the difference between adjusted and unadjusted nightlights is used as a proxy for expenditure on electricity with varying time and zone fixed effects

The proxy estimation of road infrastructure on productivity of capital is presented in Table 3.4. A 10 percent increase in road infrastructure leads to a significant 0.3 percent increase in marginal productivity of capital. From the instrumental variable regression we saw we do not have a strong evidence that the channel of this effect is through reduction of transport cost. The other channel through which roads affect capital productivity is through agglomeration caused by entry of firms as in Shiferaw et al. (2012). They confirm that road infrastructure increases entry of new firms. The agglomeration following in this entry could be the channel at work here. It is however important to further look at the possible channels through which road infrastructure benefits productivity.

In summary, the magnitude of the effects of human capital and power are higher which road infrastructure positively affects capital productivity through channels other than transport cost. We can identify further research areas and infer a few policy implications from these results. With regads to human capital it is important to further study skilled labour mobility between regions. This is important to understand the supply of skilled professionals to firms. It would also help inform education investment strategies. Another potential area of research is to better understand the channels One implication for the government to invest more on availability of professionals and technicians and ensure a consistent supply of electric power to enhance productivity of capital.

3.6 Conclusion

Capital does not flow from rich to poor countries as expected in spite of the fact that capital shortage implies high capital productivity. This is a paradox first introduced by Robert Lucas in 1990. Various explanations have been forwarded for the paradox since then ranging from capital market imperfection on the one side and low quality of institutions, infrastructure and human capital in developing countries on the other. The existing empirical evidence is based on mostly cross country analysis which is prone to bias arising out of the strong assumption of shared technology and the obscurity of nuanced firm heterogeneity. More recently micro level analysis is used to identify misallocations and distortions. The channels through which infrastructure and human capital help increase the productivity of capital in developing countries have not been studied.

In this paper, we have attempted to explain the paradox by approaching it from

a firm level and developing country perspectives. We use a unique firm and product level productivity estimates to recover marginal productivity coefficients. We construct the firm-year level marginal productivity estimates. We estimate the effects of human capital, road and power infrastructures on the marginal productivity of capital. To address endogeneity arising out of simultaneity and omitted variable bias we use instrumental variable regression. For human capital we use regional level supply of professionals and technical employees as instrument along with zonal fixed effects. In order to address the endogeneity of transport cost we use the road length weighted by elevation as an instrument. For power we use differences in the frequency of nightlights to measure the fluctuation of electricity supply. Zonal and time fixed effects are used to further account for fixed factors specific to location and time.

We find that human capital and power have strong significant effect with 9 percent and 4 percent effects respectively on productivity of capital for a 10 percent increase. The instrumental variable estimation of transport, however, is not significant as transport cost and road infrastructure are weakly correlated. We look at the effects of roads on productivity by including it in the estimation directly. This reveals a significant positive effect on productivity of capital. This indicates that roads benefit productivity not through the reduction of transport cost but through another channel. This requires more enquiry. One explanations is that better roads leads to entry of firms leading to agglomeration effects.

The results are robust to different specifications and fixed effects. We can take away a number of areas for further research. skilled labour mobility is one area of potential study as it is important to understand its response to firm's demand. In addition, the relationship of road infrastructure with agglomeration and productivity of capital is a potential study area. This will help better understand the channel through which road infrastructure affects productivity. We can also deduce some policy implications. Ensuring the reliable supply of power through more investment in energy would increase the productivity of the scarce capital. An educational policy that leads to the supply of more professional and technical human capital will benefit firms more.

4. THE GLOBAL GENDER PAY GAP

For some time almost every country has been a signatory to the Equal Renumeration Convention (1951), committing them to the *"principle of equal remuneration for men and women workers for work of equal value"*.[1] The last century saw enormous progress, what Goldin (2014) terms 'the grand gender convergence', but, the evidence suggests that despite such laws, a substantial pay gap remains. In the OECD, where it might be expected to be smallest, the average pay-gap (the difference between female and male median wages, divided by male median wages) remains over 15%, and it is as large as 37% in South Korea.[2] Outside of the OECD, inequality is often even higher.

This paper introduces a new measure of gender pay inequality (GPI) based on factor shares, which we term the labour share ratio. This is, the labour share of income of women – the compensation of women workers as a share of value added, divided by the labor share of men. The idea is simple: one implication of 'equal pay for work of equal value' is that the ratio of pay to value added should be the same for men and women. Our argument is that imperfect competition in labor and product markets mean that workers of both genders must bargain over their share of output. The extent to which male workers received more, *ceteris paribus*, reflects differences in the relative bargaining strength of men and women. Our measure is therefore a deviation from this minimal definition of equality.

This approach has three key advantages. Firstly, by focusing on the share of the value added we are able to abstract from cross-country variation in the determinants of value added that normally make meaningful cross-country and intertemporal comparison difficult. Secondly, this also makes aggregation meaningful and we are able to present estimates for total global GPI. Finally, our approach relies on well-understood data: the data that make up GDP statistics.

[1] The USA is a prominent exception but has had a similar commitment since the 1963 Equal Pay Act.

[2] See, https://www.oecd.org/gender/data/genderwagegap.htm.

Using these extant data means that we are able to measure changes in gender inequality over a period of up to 40 years, for over 70 countries.

Using these data this paper studies how GPI varies across countries, and its changes over time. It also studies the evolution of aggregate global pay inequality. We find that whilst the gender pay gap has been slowly shrinking in most countries, the relatively high birthrate in more unequal countries means that aggregate inequality has increased and will continue to increase until around 2050. We also find that the current aggregate gender pay gap is equivalent to 1,200 Million Women working for no compensation whatsoever. This paper thus also contributes to the literature studying aggregate income inequality, particularly the work of Jones (1997), Milanovic (2002) and , Sala-i Martin (2006) as well as the more recent work of Milanovic (2015). We conduct a similar analysis, but for GPI. One important implication is that previous estimates may have under-estimated the inequality of the global distribution of income.

Thirdly, this paper contributes to the literature that studies the relationship between gender inequality and development. We exploit the considerable time period covered by our data to study the causal determinants of GPI. Specifically, we test the Modernization hypothesis (see, Ronald Inglehart, 2000), which states that rising living standards and political emancipation cause changes in values leading, *inter alia*, to improvements in gender equality. This question is important as it informs whether GPI is a symptom of underdevelopment or a separate pathology.[3] Our IV estimates suggest that a tripling of incomes would be required to achieve an increase from a labor share ratio of 0.4, typical of many middle-income countries, to equality. But, we find little evidence of any effect of democratization or the political power of women. Thus, while a substantial literature shows women's political empowerment leads to improved gender equity, such as Duflo (2004), we find no causal evidence that this is true for GPI at the national level. Other results suggest that whilst free-trade improves GPI, financial liberalization achieves the opposite.

This chapter is organized as follows. The next section outlines the properties of our factor-shares based index and the data we use. Section 4.2 describes patterns of gender equality around the world and provides estimates of aggregate global gender gap. Section 4.3 studies whether rising incomes and democratization will

[3] A stronger alternative hypothesis in the literature, is that gender inequality may be a path, via a more competitive manufacturing sector, to growth.

reduce gender inequality. Section 4.4 briefly concludes.

4.1 Measuring Gender Pay Inequality

Gender Inequality (GI) takes many forms and has many causes. In the labor market there are two key margins. The first is differences in pay for the same value of work. The second is differences in value created due to occupational choice.

Differences in pay for work of equal value has itself two forms. The first is pure discrimination: women are sometimes paid less for the same work of equal value in the same job. The second is more subtle: roles that are predominantly filled by women may pay less than jobs creating the same value filled by men.

The second margin is occupational choice which leads to gender pay differences as women often disproportionately have jobs that create less value. This again is due to two reasons; firstly differences in opportunity; and secondly differences in preferences. Differences in opportunity vary from the obvious effects of social prohibitions on who can do which jobs, to more subtle requirements such as selection mechanisms that implicitly favor men. There are also often differences in educational opportunity, access to social-networks, glass-ceilings, and so forth. Gender differences in expected household production will also impact on hours worked: women also often engage in more (unmeasured) household production (see, Hook, 2010), and this impacts upon their pay and advancement. Recent evidence also suggests that it may also reflect differences in preferences for example over leisure, prestige, or competition. Although to the extent that a concern for prestige is not a determinant of value created in a role this is too a form of discrimination.[4] Of course, the two margins may interact – for example, women's educational choices will be distorted by pay discrimination.

Gender inequality is thus the product of differences in pay for the same value of work, and differences in the value created. The labor share measure proposed in this paper captures purely the former. Let each individual in a population of F

[4] An important recent literature studies how differences in preferences for risk (see, Bertrand, 2011), working hours (see, Goldin, 2014), competition (see, Fershtman and Gneezy, 2001, Niederle and Vesterlund, 2007, Gneezy et al., 2009, Buser et al., 2014); the welfare of others and prestige affect occupational choice. Other studies consider the role of yet more subtle factors such as additional absenteeism due to the menstrual cycle (see, Ichino and Moretti, 2006) or the role of outside offers (see, Blackaby et al., 2005).

women and M men each receive a wage w_i where $i \in \{1, \ldots, F+M\}$. Then,

$$w_i = \lambda_i v(\theta_i) \tag{4.1}$$

where θ_i is a vector of individual characteristics. Denoting $v_i = v(\theta_i)$, we note that $\lambda_i = \frac{w_i}{v_i}$ is the labor share of individual i. The lack of a subscript on $v(\theta_i)$ reflects the intuition that in the same job men and women with equal characteristics should create the same value.[5] Differences in λ_i reflect differences in pay for work of the same value and thus are equivalent to the definition incarnate in the Equal Renumeration Convention (1951). Thus, if there is no gender inequality in terms of equal pay for equal value then (4.1) implies that the average male labor share, $\overline{\lambda_M}$, should be equal to the average woman's labor share, $\overline{\lambda_W}$. Or, equivalently, that their ratio is equal to one:

$$\rho = \frac{\overline{\lambda_F}}{\overline{\lambda_M}} = 1. \tag{4.2}$$

The measure of gender inequality that we use in this paper is $|1-\rho|$, the (absolute value of the) difference between the observed ratio and one.[6]

4.1.1 Measuring the Labour Share

An important advantage of the labor-share approach is that it may be calculated using System of National Accounts (SNA) and International Labor Organization (ILO) data. That is the data used to calculate national accounts statistics. As we discuss below we augment these data with data on hours worked from the United Nations Industrial Development Organization (UNIDO). A naive calculation of the labor share may be computed purely following (4.1) and using data on value-added and compensation per worker from the SNA data.[7] Thus, using E and SE superscripts to denote the employed and self-employed respectively a simple measure of the labor share is:

$$\overline{\lambda}^E = \frac{\sum_i w_i^E}{\sum_i v_i^E + \sum_i v_i^{SE}} \tag{4.3}$$

[5] There are some exceptions to this, such as gender differences in the ability to use a plough, (see, Alesina et al., 2013).

[6] We treat the few observations in our data for which the female labor share exceeds the male symmetrically as a deviation from equality and thus use the absolute value of $1-\rho$.

[7] In principle one might be interested in other moments, but we focus on the average.

However, such a calculation will be biased as it will attribute all of the returns to self-employment to capital. This will be problematic in our context if the self-employed are disproportionately male or female. Gollin (2002) suggests assigning to self-employed workers the same average wage as employed workers.

$$\overline{\lambda}^{E+SE} = \frac{\sum_i w_i^E + \overline{W^E} N^{SE}}{\sum_i v_i^E + \sum_i v_i^{SE}}. \tag{4.4}$$

where, N^E and N^{SE} are the number of workers in employment and self-employment respectively. There is a further issue which may be important in our context and this is the number of hours worked. This calculation assumes that the number of hours worked is the same in self-employment and that for a given hour of work the value-added is the same. The evidence suggests (see, Hook, 2010), women are responsible for a disproportionate share of household production and thus they may engage in less market production. The evidence also suggests that part-time workers are more likely to be self-employed. Thus failing to account for this difference is likely to overstate the labor share. Conversely, if part time work were associated with a weakened bargaining position, then failing to adjust for hours worked may understate it. We thus use data from the ILO to calculate an alternative measure of the labor share, $\overline{\lambda}_H^{E+SE}$, that attributes to the self-employed the average hourly wage of the employed multiplied by the average number of hours worked by the self-employed.

Thus, if W_H^E is the hourly wage of the employed and H^{SE} is the number of hours worked by the self-employed then the hours and selfemployment adjusted labor share is given by:

$$\overline{\lambda}_H^{E+SE} = \frac{\sum_i w_i^E + \overline{W_H^E} H^{SE} N^{SE}}{\sum_i v_i^E + \sum_i v_i^{SE}}. \tag{4.5}$$

We maintain the assumption that average wages per hour are the same for the employed and the self-employed. Any violation of this assumption will lead to biases in our estimate of the labor share. Given that our focus is on the ratio of the labor share of women to men it is useful to think about the possible bias of this ratio. We are most concerned that this bias will be negative, leading us to overstate gender inequality. This will be the case only if hourly wages are higher for men but lower for women in self-employment compared to employment or vice-versa. If both women and men are paid more or less per hour in self-employment than employment then the bias will be positive, leading us to under-estimate

gender inequality. Thus, for there to be a substantial negative bias the pay difference between employment and self-employment would need to be large and of opposite sign for men and women. One way in which this might happen is due to differences in occupation. To address this concern, as well as for reasons of data availability, we calculate $\overline{\lambda}_H^{E+SE}$ solely for the manufacturing sector where it is harder to imagine such a large distortions persisting.[8]

Thus, we consider two measures of gender inequality the 'unadjusted' measure is calculated using data for the entire economy according to (4.3). The 'adjusted' measure is calculated according (4.5) using data only for the manufacturing sector and is adjusted both for self-employment and for hours worked. As we shall see in the next section, the qualitative patterns in the two measures are extremely similar.

Our approach relies on well-understood data: the data that make up GDP statistics. Whilst, these data have been criticized, particularly for Sub-Saharan Africa (see, Jerven, 2013), they are compiled according to a well-defined standard designed to ensure comparability across countries and years.[9] This is a considerable advantage compared to the meta-analysis approach taken by Oostendorp (2009). Perhaps most importantly, the ratios obtained by calculating (4.2) using (4.3) and (4.5) are dimensionless and thus do not suffer the from an index-number problem.

4.2 Gender Inequality around the World

This section presents the labor shares data and establishes the existence of a large global gender gap. It begins by presenting the evidence that women do indeed have a lower labor share, the extent to which this varies across countries,

[8] To see this, we may define the bias in the labor share as $E[\overline{\lambda}_H^{E+SE} - \lambda^{*E+SE}]$. Then the bias of the associated labor share ratio ρ is given by

$$E[\rho - \rho^*] = \frac{(\overline{\lambda}_H^{E+SE} - \lambda^{*E+SE})_F}{(\overline{\lambda}_H^{E+SE} - \lambda^{*E+SE})_M} = \left(\frac{\overline{W}_F^E - W_F^{SE}}{\overline{W}_M^E - W_M^{SE}} \frac{H_F^{SE} N_F^{SE}}{H_F^{SE} N_M^{SE}} \right) / \frac{\sum_{i \in F} v_i^E + \sum_{i \in F} v_i^{SE}}{\sum_{i \in M} v_i^E + \sum_{i \in M} v_i^{SE}} \tag{4.6}$$

. All of these terms are weakly positive and observed directly except for $\overline{W}_F^E - W_F^{SE}$ and $\overline{W}_M^E - W_M^{SE}$ Thus, only if $\overline{W}_M^E - W_M^{SE} < 0$ and $\overline{W}_F^E - W_F^{SE} > 0$ or vice-versa will the labor share ratio be biased downwards, overstating inequality. Thus, in practice, the bias is very unlikely to be negative.

[9] Moreover, our estimates require sufficiently detailed GDP data that we are often forced to exclude those observations which Jerven (2013) argues should be taken least seriously.

and how this difference has tended to persist through time. It then moves on to document and discuss the aggregate extent of global gender inequality.

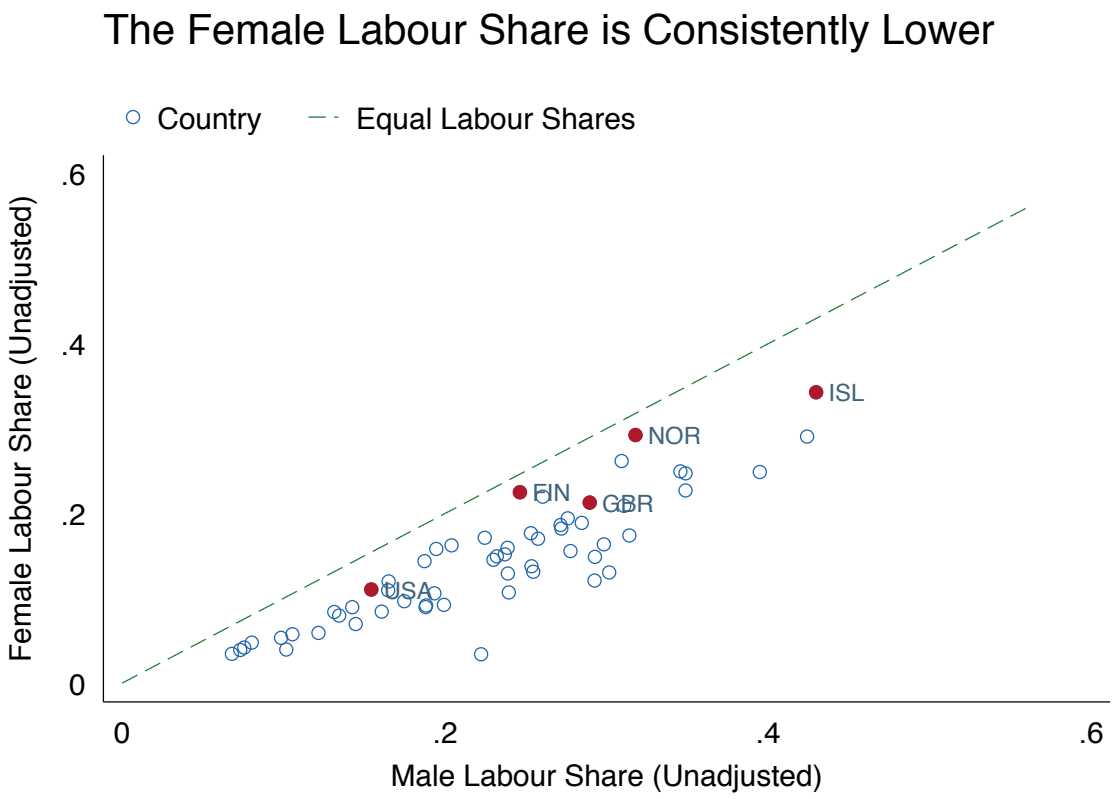
As discussed previously, we calculate an adjusted, λ_H^{E+SE} and an unadjusted, λ^E measure of the labor share. We then, as in (4.2), may correspondingly define an adjusted, ρ_H^{E+SE}, and an unadjusted, ρ^E, measure of the labor share ratio. Figure 4.1 contains a scatter plot of the average labor share of men on the x-axis and the labor share of women on the y-axis by country for 2005. Hence, the dashed 45^{deg} line represents $\rho = 1$ or average gender equality. It is immediately clear that in every country $\rho < 1$. Perhaps as expected, the countries closest to the line are Nordic countries such as Norway and Finland. The country with the absolute highest value of the female labor share is Iceland. The absolute value of the female labor share is also important as the relative shares of labor and capital share have important implications for inequality (see, Piketty and Saez, 2003). One, sometimes neglected, implication of this is that if gender differences in capital ownership mean that capital income disproportionately accrues to men, then a higher (female) labor share ratio will reduce the inequality of total (capital+labor) income.

There are a substantial number of countries where the labor share is low for both men and women, but Egypt stands out in that the labor share of men is at the average and that of women is close to zero.

A similar scatter of male and female labor shares, but using the adjusted data, is reported in Figure 4.2. The key finding, that $\rho < 1$, remains true *a fortiori*. The average distance from the line of average equality is now larger. We now find, perhaps again unsurprisingly, that the average female labor share is highest in the Netherlands. But, perhaps less expectedly ρ is now highest in Portugal. We also observe that higher values of ρ are not a simple function of development. The labor share ratio of Russia is better than that of Japan or Ireland. The unadjusted data suggested that female labor shares were close to 0 in a number of countries. The adjusted data shift the average labor share of both genders upwards, but those of men by more, suggesting that the unadjusted data may understate gender inequality.

Despite the substantial inequalities shown by Figures 4.1 and 4.2 the mean country is more equal today than it has been in the past. Figure 4.3 plots both the adjusted and the unadjusted data since 1970 and shows that there has been an

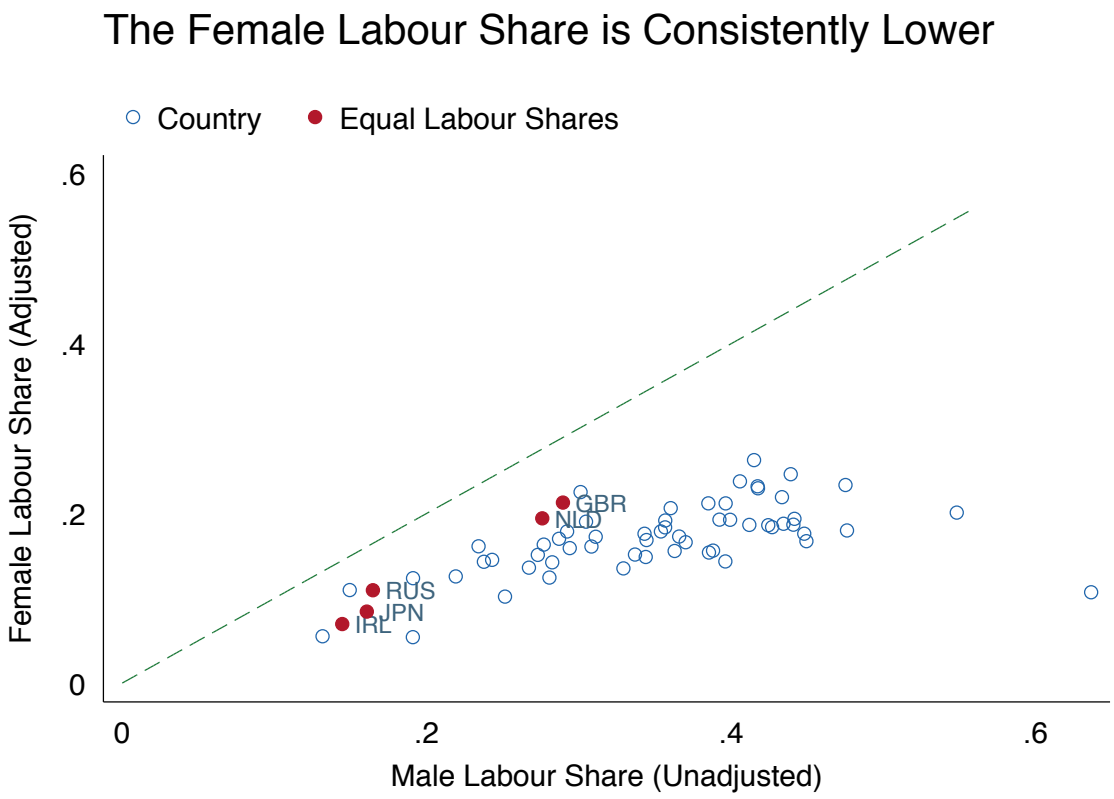
Fig. 4.1: Scatter Plot of Female and Male labor Share in 2005 (Unadjusted Data)



increase of over 10 percentage points in both series. This in fact will understate actual progress as our sample contains fewer, and on average richer, countries in the 1970s than later on. Nevertheless, as revealed by Figures 4.1 and 4.2 overall progress has still been slow. One notable feature of the series is that they are non-monotonic suggesting that gender inequality sometimes increases. One possibility is that this may be related to the economic cycle with gender equality suffering during recessions. We investigate this formally in Section 4.3, but find no evidence that this is the case. A second notable feature of the data is that they show a marked up-tick at the very end of our period. This might reflect the increased attention given to gender-equality by the Millennium Development Goals in Less Developed Countries, or the achievements of long-standing campaigns for equal pay in richer countries. Regardless of the cause, it may signal accelerated convergence in the future.

One question that studying the average of ρ cannot address is whether the observed improvement represents a uniform increase or is concentrated in a

Fig. 4.2: Scatter Plot of Female and Male labor Share in 2005 (Adjusted Data)

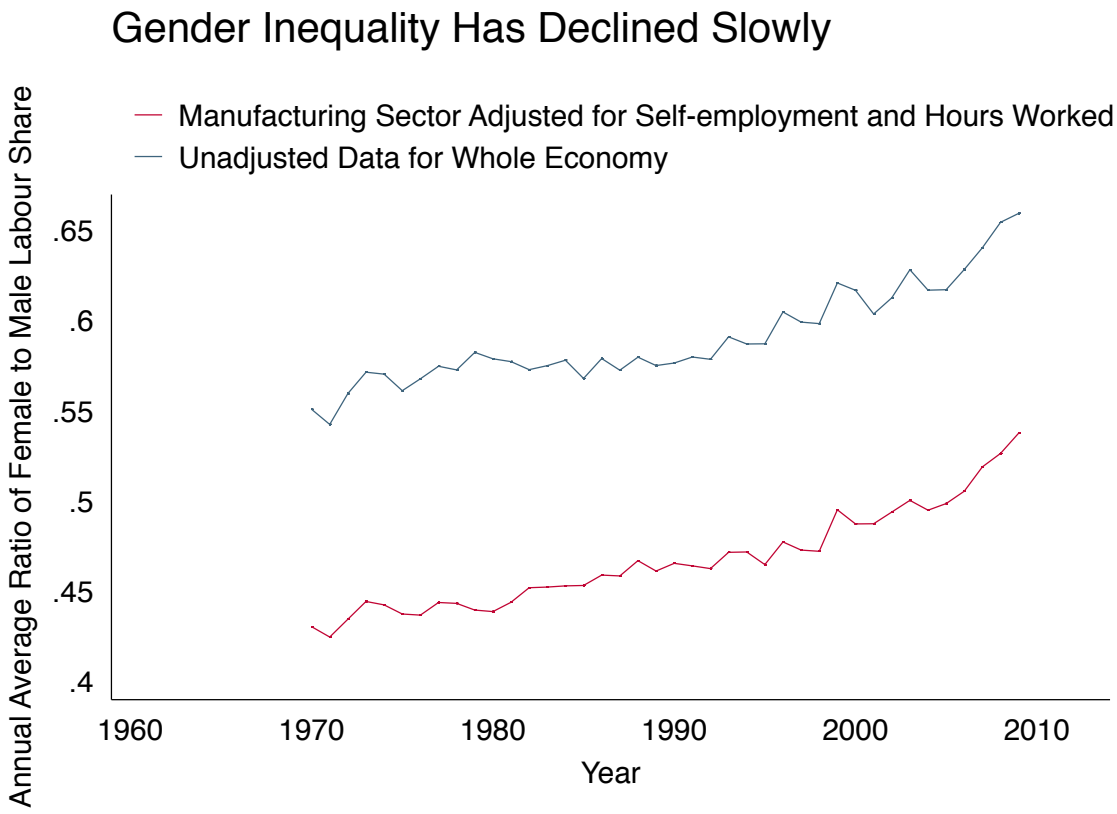


subset of countries. To understand this Figure 4.4 shows how the distribution of ρ has changed between 1975 (solid lines) and 2005 (dashed lines). For both ρ^E and ρ_H^{E+SE} the distribution has shifted substantially to the right as we saw previously. Interestingly, whilst both the distributions have become less left-skewed there remains a tail of highly unequal countries, particularly in the unadjusted data. Comparing the distributions of the adjusted and the unadjusted data confirm the suggestion in Figure 4.3 that the unadjusted data may tend to understate gender inequality.

Finally, we consider the distribution by income group. Using the World Bank categorization, Figure 4.5 plots the distribution of the labor share ratio for High, and Upper and Lower Middle Income countries. Immediately, we can see that, as we expect, the High Income distribution is right-most, and the Lower distribution left-most. But, there is considerable overlap and heterogeneity within categories. The difference between the High Income and the Upper Middle Income categories are relatively minor compared to between these and the Lower Middle category,

but even this difference is second order compared to the within category variation. Thus, it would seem that Gender Inequality is not an automatic consequence of development. We return to this in Section 4.3.

Fig. 4.3: Cross-Country Mean of ρ_H^{E+SE} and ρ_H^{E+SE} overtime.

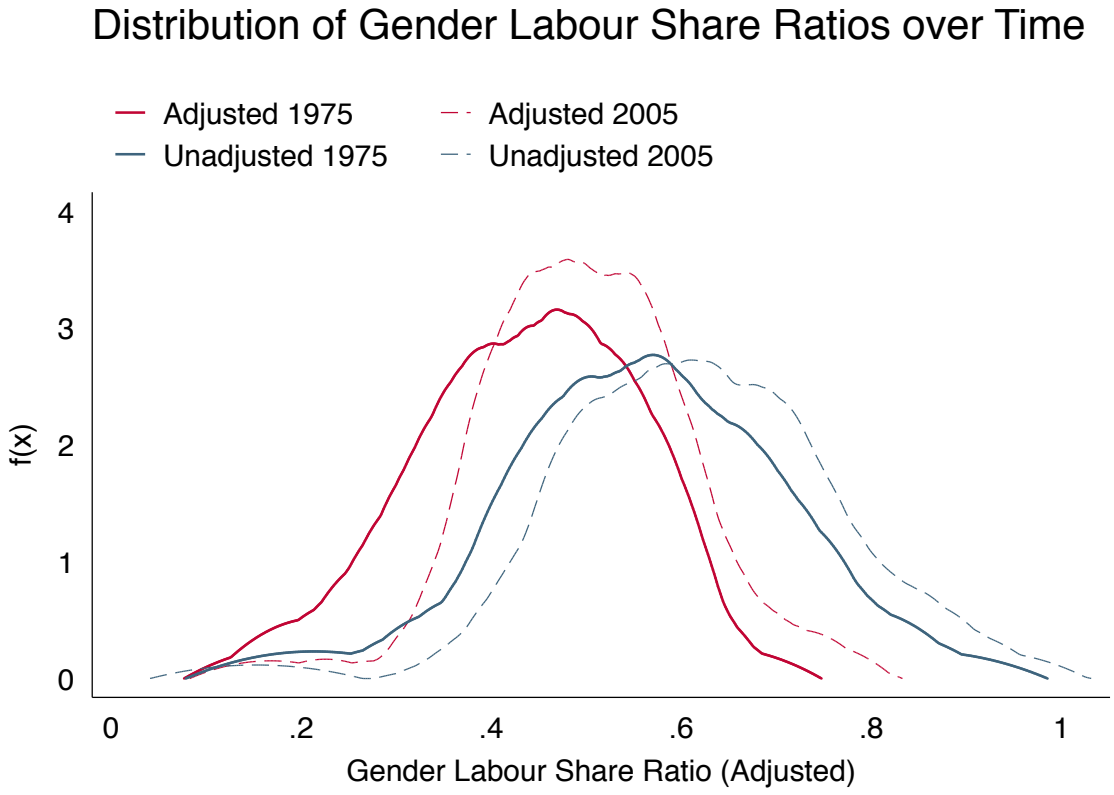


4.2.1 Aggregate Inequality

Having established the key features at the country level the remainder of this section focuses on the distribution of gender inequality at the population level. That is, we ignore the average differences between countries that were previously our focus, and now consider the total global extent of gender inequality ignoring national borders. Differing population sizes and population growth rates mean that the moderate improvement in Gender-Inequality we find at the country level need not imply that labor market inequality has improved for the average woman.[10] Measuring overall gender inequality requires calculating the total

[10] The literature on aggregate global income inequality shows that differences between nations are able to explain the majority of global inequalityMilanovic (2015). Thus, Jones (1997), Milanovic

Fig. 4.4: Distribution of ρ_H^{E+SE} and ρ_H^{E+SE} in 1975 and 2005.

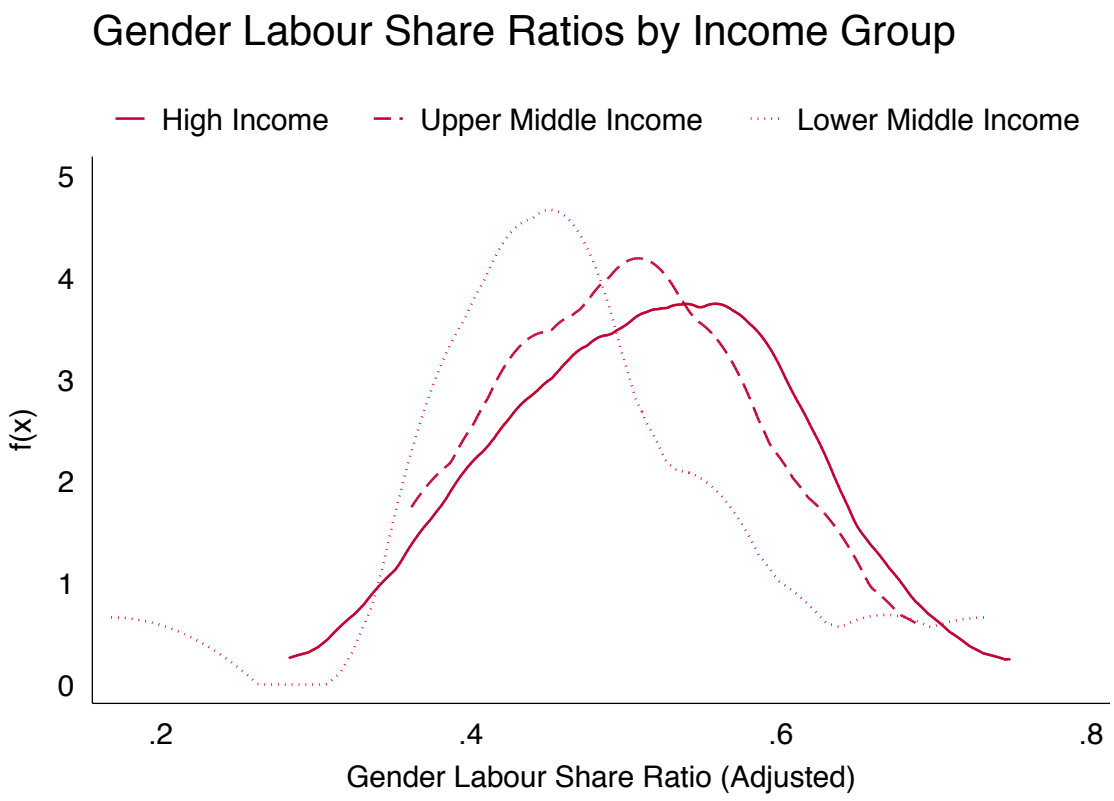


deviation from gender inequality in each country and aggregating these across countries. If we were able to observe the difference between each individual woman's renumeration and the counterfactual she would receive if she were an equally productive man in the same job, $1 - \rho_i$, then total world gender inequality $\tilde{\rho}_W$ would be simply:

$$\tilde{\rho}_W = \sum_{c \in C} \sum_{i=1}^{N_c} |1 - \rho_i| \tag{4.7}$$

(2002) and Sala-i Martin (2006) show that, despite rises in within country inequality rapid growth in China and to a lesser extent India have reduced total world inequality.

Fig. 4.5: Distribution of ρ_H^{E+SE} by Income.



Where C is the set of countries and N_c is the population of Country c. Given we can never observe the necessary counterfactual, we consider two alternatives:

$$\tilde{\rho}_W^S = \frac{\sum_{c \in C} \frac{N_c}{N} \sum_{s \in S} \frac{N_s}{N_C} |1 - \overline{\rho_s}|}{\sum_{c \in C} N_c} \tag{4.8}$$

And:

$$\tilde{\rho}_W^M = \frac{\sum_{c \in C} \frac{N_c}{N} |1 - \overline{\rho_C}|}{\sum_{c \in C} N_c} \tag{4.9}$$

Equation 4.8 calculates the average inequality in country C as the working-age female population weighted average of the labor share ratios in each sector $S \in Agriculture, Industry, Services$. This measure will capture gender inequality

across the entire labor force, but as discussed above, will be misleading if differences in hours worked and self-employment are important. We thus also compute average inequality based on inequality in the manufacturing sector as in Equation 4.9. One complicating factor is how to treat those not engaged in market-work. It may well be that those who are not engaged in market-based labor would receive a lower than average share of valued-added. The alternatives, given the data available, are either to assign a notional value of ρ to these individuals, or to exclude them and risk under-estimating gender inequality. Here we choose the latter, but note that this will mean our estimates of total inequality are likely to be conservative. A second complicating factor, is that we do not measure the labor share at all for some countries, in some years. In this case we impute the $20th$ percentile of the distribution of country averages. This is again a conservative assumption because the countries that do not collect the necessary data tend to be LDCs and ρ is positively correlated with income. We alternatively use the median, which would imply, implausibly, that countries are missing approximately at random, but the key inferences are unaffected.

Figure 4.6 plots $\overline{\rho_S}$ and $\overline{\rho_M}$. It is clear that global GPI is increasing. This is because, whilst the average country demonstrates improving gender inequality over the period, population growth rate differences mean that the average woman lives in an increasingly iniquitous countries. Any suggestion that this difference in the populated weighted and unweighted averages is merely a statistical nicety is dispatched when we consider the results quantitatively. The most straightforward interpretation of $\overline{\rho}$ is that it is the amount of inequality equivalent to a given number of women not being paid at all. Thus in 1970, on the more conservative economy-wide, but unadjusted measure, global inequality was equivalent to 600 million women being unpaid (and the rest receiving the same average labor share as their male equivalents). Comparison with the green line describing the total global population of women reveals that these 600 million women were 60% of the then population of working age women. By 1990, inequality was equivalent to 800 million unpaid women, out of a population of around 1.5billion. Thus representing an improvement in the percentage but not the aggregate. By the end of our period the number of unpaid women is approaching 1 billion, which is still just under half the total population. On the basis of our preferred manufacturing measure, initial inequality was equivalent to 700 million unpaid women. By 2010 this had risen to $1,200$ million women, or about the entire female population of India and China.

These figures are shocking. Inequality equivalent to a lower bound of 1200 million women working for nothing, is also equivalent to one third of all women working for nothing. These figures are particularly shocking given that they are by construction conservative. The factor shares approach means we are abstracting from the well documented differences in productivity due to gender differences in education and employment opportunities discussed above and accounting for these would only further increase the measured departure from equality. Moreover, the over 2000 million increase in global population by 2050 is almost entirely expected to occur in LDCs, particularly in Africa, suggesting that unless rapid improvements are made in these countries aggregate gender inequality will continue to increase for the foreseeable future.

One potential criticism of these estimates is that they treat women who are not recorded as in the labor force as receiving the same share of their value added as women better recorded. This assumption is a substantive one – differences in the extent or form of labor market activity likely reflect available market opportunities and other forms of gender inequality more than it represents gender differences in preferences or productivity. To justify this claim, it is instructive to consider two reasons why such an assumption may be seen to lead aggregate inequality being to overstated. The first is that women may disproportionately work in sectors where the labor-share is not meaningful or well measured. The second, is that women may not be in the labor force and thus not facing any inequality.

The first reason, is an argument that that for many women inequality may be overstated by the average, measured, labor share. It is based on the observation that particularly in LDCs, women disproportionately work in the home and or in subsistence farming. The claim is then that we overstate inequality when we attribute the average labor share ratio to such women, whose economic activity and thus whose labor share is not well measured, and whose labor share may in fact be higher. Our approach, then attributes to women the inequality they would face were they to enter the conventional labor market. To the extent that women are able to choose whether they enter this market, that a substantial number of them do not suggests that their (effective) pay is higher in the subsistence or household sectors. Yet, this would not be true for all of them were inequality lower. Moreover, by repressing moves into other sectors, inequality also holds down average productivity in subsistence agriculture, at a cost to the women

working in it.

Moreover, a substantial body of research has demonstrated that these traditionally female jobs tend to be poorly compensated in both absolute and proportionate terms.[11] Thus, it is hard to see that women working in these sectors would choose to do so, for the same reward, in the absence of gender discrimination.

The first reason argued that for many women inequality may be overstated, the second reason argues that it is inappropriate to attribute any inequality at all to women, not participating in the labor market. This argument, that those not in the labor market do not face labor market inequality, is perhaps a tenable philosophical position. But, as an empirical matter the global population of such women of leisure is relatively small. Normally, married women in rich families in rich countries. We conclude then it is hard to argue that there are a substantial number of women for whom the labor share ratio is irrelevant. Nevertheless, Figure 4.7 displays the results of deflating our measure by the female labor market participation rate. This is only available from 1990 onwards, and averages around 0.5, with a small increase from 0.49 to 0.53 over the period. Unsurprisingly therefore, measured inequality is now reduced by around one half, and the rate of increase similarly falls. Note, however, that this measure is extremely conservative as it assumes that there is no discrimination for all women who work either in the home or informally. This is contrary to all of the available evidence, and for that reason this measure will systematically understate inequality. Our preferred interpretation is that given there is some ambiguity over the labor share ratio in non-market sectors of the economy this calculation represents the lower bound, given that it is implausible that the unmeasured women have labor share ratios larger than 1.

Labor-market inequality is only one aspect of gender inequality, however, and in the next section we show that our measure is correlated with other dimensions of inequality suggesting that gender inequality, more broadly defined, may also be getting worse not better.

[11] For example, Goldin (2014) shows that this margin of discrimination is still substantial, albeit decreasing, in the US.

Fig. 4.6: Aggregate Global Gender Inequality

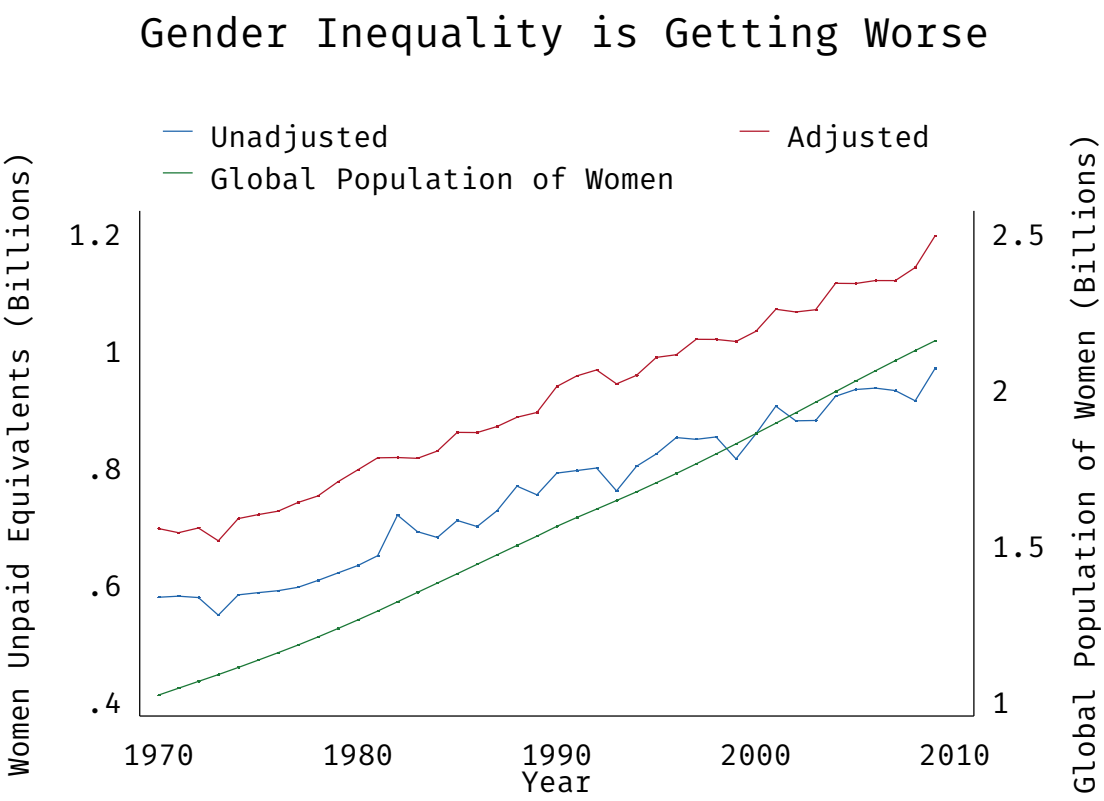
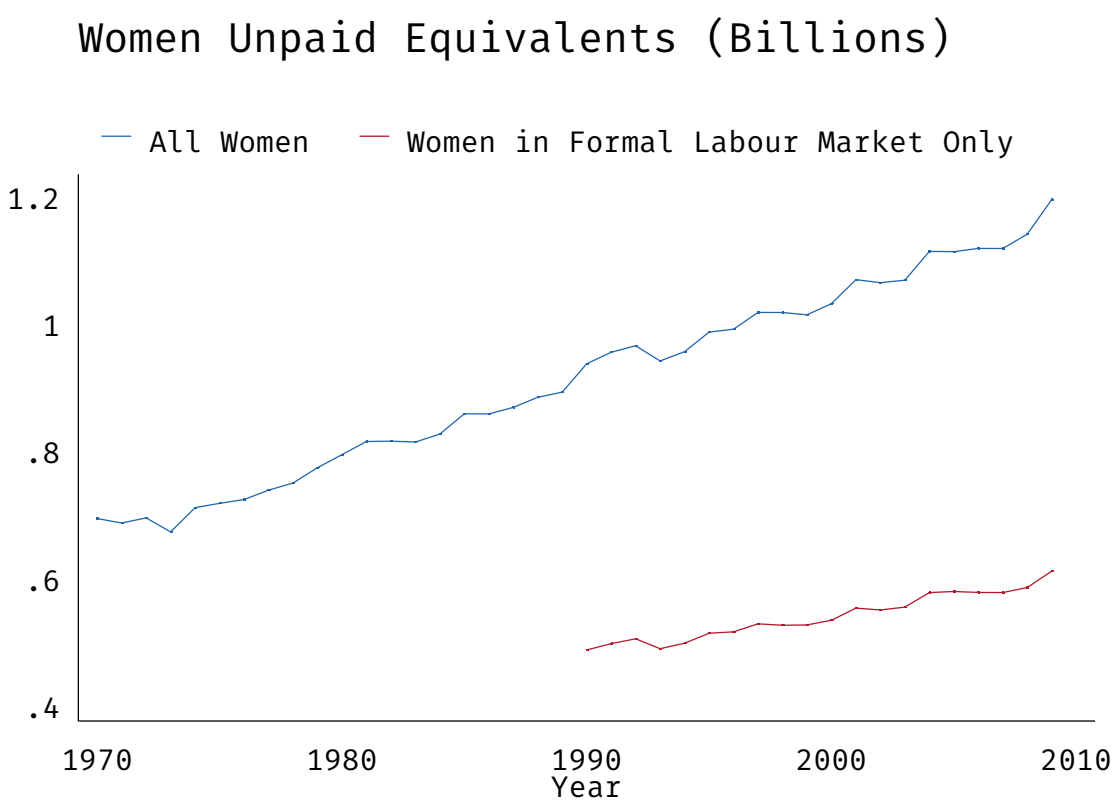


Fig. 4.7: Aggregate Gender Inequality – Adjusting for Female labor Force Participation



4.3 Causes of Gender Inequality

This section studies the causal determinants of gender inequality. In particular we ask whether increased incomes improve gender inequality, and whether democracy and more specifically the political agency of women lead to reductions in descrimination. These questions are important for at least two reasons. Firstly, if it is the case that increased incomes rapidly lead to improvements in gender equality then this suggests that convergence in income per capita will lead to a rapid reduction in aggregate inequality. Equivalently, it also means that women in the LDCs will benefit substantially from growth. Alternatively, if improvements in living standards alone do not lead to reductions in inequality then this suggests that women will benefit comparatively little from development and that aggregate inequality may continue to rise for the foreseeable future.

A recent and prominent literature has considered how female empowerment may lead to economic development, which may in turn lead to further improvements in Gender Equality. A key issue in this literature is whether such feedback effects between gender empowerment and growth are sufficiently large to give rise to a virtuous circle of increasing women empowerment and increasing growth. Doepke et al. (2012) outline a model in which this takes place, and Fernández (2014) presents theory and evidence that as development takes place men become increasingly concerned about their daughters, leading to greater property rights for women. de la Croix and Vander Donckt (2010) consider how greater equality would lead to lower fertility thus hastening the demographic transition crucial for development. Relatedly, Doepke and Tertilt (2014) consider theoretically the effects of targeting transfers to women on development. Seguino (2000), Blackden et al. (2006) present cross-country evidence that there is a positive relationship between the two. But, Duflo (2012) cautions that the empirical evidence that feedback effects may be insufficient for 'take-off' and that a 'continuous policy commitment to equality for its own sake may be needed'.[12]

[12] A largely separate literature studies the effects of gender equality on growth. Partly due to limited data availability, much of it has focused on the effects of educational inequality on growth Klasen (2002), Lorgelly (2010) but Dollar et al. (1999), Klasen and Lamanna (2009) do find that gender differences in labor market participation also retard growth. Others have studied the effect of trade-liberalization or globalization on gender equality. Oostendorp (2009) finds that growth as well as trade and investment liberalization tend to be correlated with reductions in gender inequality – particularly in poorer countries. Additional evidence is provided by Neumayer and de Soysa (2011), Chen et al. (2013), Potrafke and Ursprung (2012), Cooray and Potrafke (2011), Richards and Gelleny (2007).

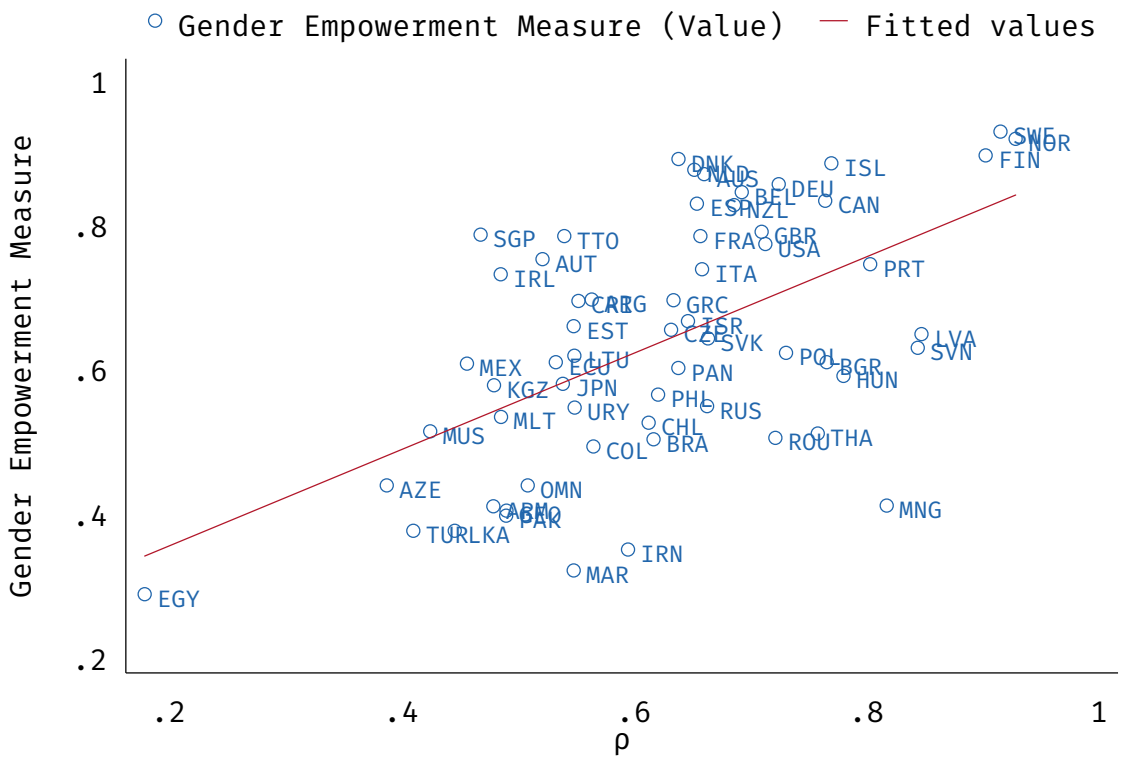
A second dimension of development is the expansion of individual rights and political agency. Women in less developed countries often have even fewer rights and less political power as well as in some cases suffering limited physical integrity and various forms of social control. Duflo (2004) studies the random reservation of seats for women on Village Councils in India and finds that increased female political power leads to the greater provision of infrastructure targeted at women. Bhalotra and Clots-Figueras (2014) find that increased political power of women leads to improved health outcomes, while Bhalotra and Rawlings (2011) show that gender inequality in investments in the health of women and girls is a key margin for the inter-generational transmission of health. We do not study these dimensions directly but as can easily be seen in Figure 4.8, which compares ρ with the Gender Empowerment Measure of the UN and studied by Doepke et al. (2012), there is a strong positive correlation between labor market inequality and other dimensions of gender inequality. Doepke et al. (2012) show that whilst the slope describing the relationship between GEM (or several disaggregated measures) and per capita incomes is positive it 'is not very steep, in particular when moving from middle-income to low-income countries.' Considering Figure 4.9 we can see that this is similarly true for labor market discrimination.

We build on this work by providing a causal analysis of the effects of income on gender-equality over the long-term. We also compare the importance of democracy versus women's political rights and agency more specifically. We assume the population relationship is linear. Then we have:

$$\rho_{it} = \beta y_{it} + \gamma D_{it} + \omega P_{it} + \lambda X'_{it} + \epsilon_{it} \tag{4.10}$$

There is also, given the literature discussed above every reason to believe that y_{it} will be endogenous and thus we employ and instrumental variable approach. The basic premise of our IV strategy is to use external macroeconomic shocks which cannot be plausibly driven by domestic changes in gender equality. We measure these shocks with four different variables. The first is the gravity-weighted average of trading partner GDP growth. To capture better the fact that many developing economies are particularly sensitive to changes in agricultural and mineral commodity prices we construct two indices that capture terms of trade changes based on ex-ante shares of each commodity in trade as in Deaton and Miller (1996). Finally, we use the presence of IMF or WB emergency assistance,

Fig. 4.8: ρ is positively correlated with GEM



which tend to be a response to financial crisis to capture the effects of these shocks. The construction of each of these instruments is described in Appendix A.1.2.

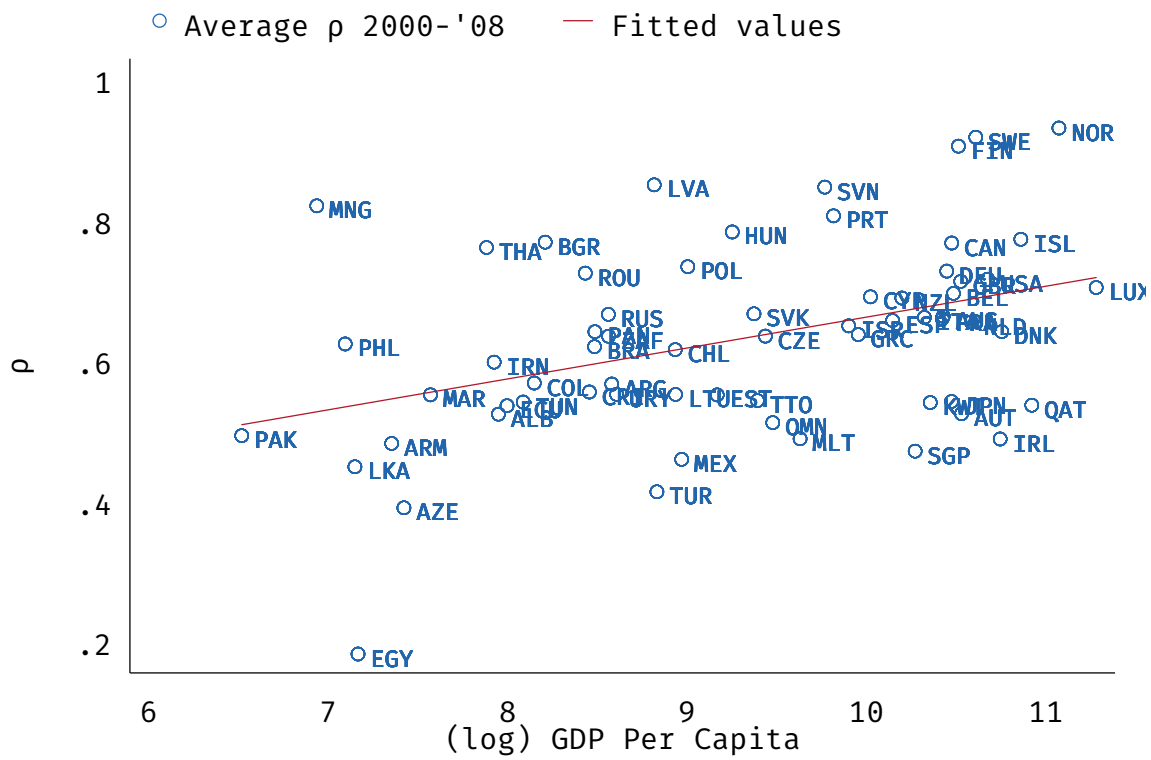
We introduce fixed effects to allow for time-invariant country-specific factors that may determine gender inequality. Given it represents in part a complex-nexus of legal, cultural and socio-economic factors gender inequality tends to only to change slowly.[13] Our specification captures this in two ways. Firstly, we allow for an autoregressive component in the error term. Secondly, to capture the idea that changes in income or democracy might be best conceived as inducing deviations from this long-run trend we include country specific linear trends.

$$\epsilon_{it} = \phi\rho_{i,t-1} + \mu_i + \tau_i t + \psi_{it} \tag{4.11}$$

Where we will assume, for now, that $\psi_{it} \sim N(0, \Sigma)$ with Σ clustered by country.

[13] For example, Doepke et al. (2012) discuss the slow evolution of women's legal and political rights in the United States and the United Kingdom since the 17^{th} Century.

Fig. 4.9: ρ is positively correlated with Income



The need to allow the fixed effects, μ_i, means that our estimates of ϕ will be biased and thus so will our other parameters. However, on average we have around 19 observations per country and thus we expect the Nickell bias to be of order $1/19$. We prefer this to the alternative of GMM estimation. However, in Table A.1.3 we employ the strategy of Acemoglu et al. (2015) and show a range of unbiased estimates obtained by fixing ϕ to a range of values.

Our key assumption is that Democracy, or more precisely democratization, is exogenous. Given that we include country-specific trends and fixed effects this is equivalent to an assumption that the precise timing of democratization, is essentially random. In fact, the difficulty of predicting episodes of democratization is by now well-established.[14]

Our initial specification is deliberately parsimonious. Whilst, including additional

[14] For example, Chenoweth and Ulfelder (2015) notes the limited forecasting ability of explanations that emphasize the structure of society rather than the agencies of particular actors.

controls might improve the precision of our estimates, if we include other variables that might also be driven by income or democracy on the right-hand side then we will again have an endogeneity problem.[15] This precludes including in our main regression other potential determinants of gender equality that have been discussed in the literature, such as Globalization and Trade or Financial Liberalization (see, Oostendorp, 2009, Potrafke and Ursprung, 2012), as there are good reasons to imagine these may well be endogenous to income and democracy. However, once we have established consistent estimates of the effects of income and democracy we then, include measures of a number of proximate causes and related outcomes, such as Globalization in Table 4.2.

We begin by estimating a restricted specification in which we omit Democracy, and constrain the set of time trends, τ_i to be equal to zero. We also ignore, for now, concerns about endogeneity and report simple OLS estimates. These results are reported in the first column of Table 4.1. We see that ϕ is positive and significant, and with a coefficient of nearly 0.7 suggesting substantial persistence in gender inequality. The coefficient on (log) GDP per Capita is also significant and precisely estimated, but is perhaps surprisingly small at 0.028. This coefficient implies that a tripling of income per capita will lead to only a long run effect 9% increase in ρ.[16] Column 2 reports the results now including country specific linear time trends. ϕ is now smaller, as should be expected, but still significant. β the coefficient on income is also slightly smaller. One, interpretation of these results is that they reflect the very slow progress made in virtually every country over the period we study. This slow progress is also reflected by the lack of any estimated impact of either the overal quality of democracy, or female political empowerment In both cases, the associated coefficients are small, negative, and imprecise. These two aspects of democracy are proxied using indices taken from the dataset produced by the V-Dem project Coppedge et al. (2016) which represents a new-standard in the measurement of different aspects of democracy, on a comparable basis, over time.[17]

Columns 5-8 of Table 4.1 relax the assumption that growth is exogenous. Columns 5 and 6 excludes the unit-specific trends, and whilst there is still no

[15] This is the so-called *Bad Control* problem.

[16] The long-run effect is given by $\beta/(1-\phi)$.

[17] The V-Dem project augments coding by a large number of individual country and period experts, with anchoring vignettes and a Bayesian measurement model to produce extremely detailed, comparable, and reproducible estimates of the nature of democracy in specific countries and years.

evidence for any effect of democracy or women's political empowerment, the coefficient on GDP per capita is now over 50% larger. Columns 7 and 8 now include the trends, and now the estimated coefficient is substantially larger, at 0.13 and 0.17 respectively. This implies a long run effect of $0.173/(1-0.442) = 0.31$ implying that a tripling of income would be sufficient to raise ρ from approximately 0.4 as in Pakistan, Mexico, or Turkey, to close to 1 as in Norway, Sweden, or Finland. Such an increase in living standards would obviously take time, but unlike the OLS coefficients these suggest that improvements in income alone could lead to wholesale improvements in women's lot. These results are robust to a wide range of alternative choices of instruments and measures of democracy and female empowerment, as can be seen in Tables A.1.1 and A.1.2 in the Appendix. We also report the Kleibergen-Paap under indentification and the Hansen J over-identification tests which overall indicate that the instruments are valid when we include time trends.

Tab. 4.1: Effects of Income and Democratization on labor Market Gender Inequality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\rho_{i,t-1}$	0.695***	0.472***	0.482***	0.466***	0.672***	0.665***	0.454***	0.442***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
(log) GDP per Capita	0.028***	0.022***	0.019**		0.035***	0.036***	0.131**	0.173**
	(0.000)	(0.009)	(0.024)		(0.000)	(0.002)	(0.011)	(0.029)
Electoral Democracy			−0.011		0.005		0.003	
			(0.198)		(0.333)		(0.809)	
Women's Political Empowerment				−0.007		0.008		0.062
				(0.694)		(0.631)		(0.113)
Estimator	OLS	OLS	OLS	OLS	IV	IV	IV	IV
Trends	No	Yes	Yes	Yes	No	No	Yes	Yes
Observations	1324	1324	1259	1319	1184	1158	1184	1158
R^2	0.686	0.222	0.233	0.210	0.689	0.688	0.135	0.049
Kleibergen-Paap p-value					0.00	0.00	0.00	0.00
Hansen J p-value					0.04	0.05	0.30	0.26

The dependent variable is $\rho_{i,t-1}$, the ratio of the female to male labor share ratio in country i and year t. $\rho_{i,t-1}$ is its first lag. *(log) GDP per capita* is the natural logarithm of per capita GDP (PPP). *Electoral Democracy Index* and *Women political empowerment index* are both taken from the V-DEM project Coppedge et al. (2016). Both indices take values in the interval 0 to 1 with higher values representing a greater degree of democracy and female political empowerment respectively. Keibergen-Paap is measure of under-identification while Hanson J tests over-identification for the IV estimates. Columns 1 - 4 report OLS estimates. Columns 5 - 8 report IV estimates using the (lag) gravity weighted trade shocks, agricultural and mineral commodity price shocks, and IMF/WB interventions. All specifications include fixed effects. Columns 2,3,4,7, and 8 additionally include country specific linear time trends.

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors, clustered by country, in parentheses.

To understand the mechanisms through which income growth leads to improvements in labor market gender equity we now augment our specification with a variety of potentially endogenous controls. These estimates are likely biased, but nevertheless may be informative about the channels through which rising living standards affect gender equality. We begin by studying the role of Globalization, using the KOF index, as in (Potrafke and Ursprung, 2012) . The estimated coefficient is small and imprecisely measured, suggesting that Globalization is not associated with the aspects of gender inequality captured by our measure. Table A.1.4 in the Appendix reports results for each of the sub-indices of the KOF Index. The key result here is that the coefficient on actual flows in the first column, which capture the Trade and Foreign Direct Investment flows studied by Oostendorp (2009), is (whilst small) positive and significant contrary to Oostendorp (2009) findings. Similarly, the coefficient on restrictions to these flows in the second column is negative and significant, but still small. A natural interpretation of these three results is that trade and investment flows are positive for gender equality, but other aspects of globalization are relatively unimportant.[18]

One much debated policy available to governments, and historically encouraged by multilateral organizations is financial reform or liberalization. Columns 2 and 3 report specifications including the indices proposed by Chinn and Ito (2006) and Abiad et al. (2010) which both suggest that financial reform is associated with worsening gender inequality, other things equal, although only the latter measure is significant. The results in Table A.1.5 in the Appendix suggest that pro-competition reforms, privatization, and international capital flows are those aspects of financial reform associated with worsening gender inequality. Columns 4 and 5 consider whether women suffer unequally from recessions, or benefit particularly from booms. However, there is no distinct effect of a recession (defined as growth of less than -2%), and while the coefficients on (log) per capita income and its square in column 5 are consistent with a quadratic relationship in column 5, only the quadratic term is significant and we can not reject the hypothesis that the two coefficients are equal. Interestingly, however, as reported in column 1 of Table A.1.6 in the Appendix, in this specification the Women's political empowerment index is now significant. This may reflect the increasing importance of women's political rights at higher levels of income.

[18] Two of the other coefficients are significant, they both have the opposite sign expected, and in every case they are very small.

As discussed above, one argument that has been made in the literature is that gender inequality might promote the growth of the manufacturing sector and exports. Columns 6 and 7 thus include the gender imbalance in the manufacturing and service sectors (the ratio of female to male employees in these sectors), but no evidence is found of any effect.

Finally, columns 8 and 9 report the results of including measures of reproductive and education equality. As discussed above, women's control of their own fertility is an important dimension of gender equality, but reduced fertility also reduces the number of children that need to be cared for, a burden often disproportionately borne by women. We thus use the fraction of the working-age population as a statistic which reflects both the recent history of fertility rates and the burden of child care.[19]. The estimated coefficient is negative as expected, and precise. It is however, in common with many of our other estimates, relatively small. A decrease in the dependency rate of 10% is only associated with an increase in gender equality of 0.0002%. Column 2 of Table A.1.6 shows that the same effect is found considering only the crude birth rate.

In column 9 we consider another key dimension of gender equality, education. Taking the ratio of female to male primary enrollment as our measure we find no effect. However, this may be because of the substantial lags between primary education and entry into the workforce. Columns 3-9 of Table A.1.6 report results using range of other measures of gender inequality in education and whilst we find significant coefficients associated with (the ratio of) expected years of schooling and tertiary education, these are not of the expected sign likely reflecting endogeneity bias.

[19] It also reflects the burdens of care for older people which also tends to fall largely on women.

Tab. 4.2: Mechanisms through which Income and Democratization affect labor Market Gender Inequality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(log) GDP per Capita	0.118**	0.140***	0.144**	0.124*	−0.529	0.144**	0.148**	0.135***	0.100*
	(0.015)	(0.005)	(0.044)	(0.058)	(0.133)	(0.021)	(0.019)	(0.005)	(0.051)
$\rho_{i,t-1}$	0.444***	0.441***	0.432***	0.449***	0.420***	0.443***	0.442***	0.446***	0.466***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
KOF Globalization	−0.000								
	(0.205)								
Chinn-Ito		−0.007							
		(0.107)							
Financial Reform			−0.015**						
			(0.020)						
Recession				−0.000					
				(0.992)					
(log) GDP per Capita^2					0.040*				
					(0.065)				
Ratio Women Industry						−0.000			
						(0.986)			
Ratio Women Services							−0.004		
							(0.545)		
Share Population 15-64								−0.002**	
								(0.021)	
Ratio Girl Primary Enrollment									−0.000
									(0.858)
Estimator	IV	IV	IV	IV	IV	IV	IV	IV	IV
Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1229	1221	967	1241	1241	950	950	1241	1087
Kleibergen-Paap p-value	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00
Hansen J p-value	0.32	0.27	0.51	0.11	0.91	0.25	0.22	0.44	0.34

KOF Globalization Index is the overall measure compiled by Dreher et al. (2008). The *Chinn-Ito Index* measures capital account openness and is normalized to take values between 0 and 1 and taken from Chinn and Ito (2006). The *Financial-Reform Index*, again normalized, is from Abiad et al. (2010) and summarizes seven different aspects of financial repression. *Recession* is defined as growth of as growth of less than -2% in a given year. *Ratio Women Industry* is the ratio of female to male employees in the Industrial Sector. *Ratio Women Services* is the equivalent for the Service Sector. *Share Population* $15-64$ is the percentage of the population aged $15-64$. *Ratio Girl Primary Enrollment* is the ratio of girls to boys enrolled in primary school. Keibergen-Paap is measure of under-identification while Hanson J tests over-identification for the IV estimates. All other details as for Table 4.1.

4.4 Conclusion

This paper has presented a new approach to measuring gender inequality in the labor market based on the ratio of the labor share of women to men. This approach corresponds precisely to the concept of equal pay for equal work, enshrined in international treaties. The resulting data are also easily compared across time and place, and we are thus able to provide new evidence about gender inequality in the labor market varies across countries and how it has evolved over time. We find that gender inequality, despite the progress documented by Goldin (2014), remains substantial at a global level. We present the first estimates of aggregate global gender inequality and suggest that this is equivalent to around $1,200$ million women working for no compensation whatsoever. Moreover, this may number can be expected to rise as population growth is concentrated on the poorest, and least gender-equal, countries over the next four decades.

The approach of focussing on factor shares provides data for around 70 countries for up to 40 years. We use these data to undertake a causal analysis of whether modernization leads to improvements in equality or whether improvements in the treatment of women in the labor market are driven by a separate process. Our IV estimates suggest that a tripling of incomes would be required to achieve an increase from a labor share ratio of 0.4, typical of many middle-income countries, to equality. We also find little evidence of any effect of democratization or the political power of women. Other results suggest that whilst free-trade improves women's status, financial liberalization achieves the opposite.

5. THESIS CONCLUSION

This thesis examines productivity and gender inequality in manufacturing firms in developing countries. Using fine grained data on large and medium scale manufacturing firms we look closely at firm and product level productivity estimation. Using this estimation we estimate the effectiveness of a typical industrial policy and explain the low productivity of capital in developing countries. We also construct a new measure of labour share using factor shares in income that is comparable across time and across countries. We present trends in gender pay inequality through the past decades.

The first chapter examines the effect of a prototypical industrial policy of providing tax incentives and cheap loans to firms based on sector of activity and location. In developing countries providing these incentives could be costly given the scarcity of budget resources. It is also commmon to believe that firms in developing countries are capital starved and policies that make capital cheaper would lead to more investment and productivity. Using very detailed data on firm activity we estimate total factor productivity of firms using the Olley-Pakes and Levinson-Petrin productivity estimation methods that help correct bias arising from possible endogeneity of firm exit and input choice decisions when investment is not continuous. Productivity estimations show that contrary to the common belief capital is not as productive and requires complementary inputs as discussed in the second chapter. We also find that material inputs have high marginal productivity followed by labour. We use alternative productivity estimation methods to check the robustness of the estimates. We use Difference in Difference to estimate the effect of the the policy on productivity, employment, capital accumulation and diversification. We find that the policy didn't have the intended effects on productivity and employment. To see why we explore the effect of entry of firms due to the policy on productivity. We find that the policy led to entry of less productive firms into the market leading to a fall in average productivity. Employment and diversification have also not responded to the policy. We find

however that firms accumulated more capital due to the policy, although they focused on more fungible capital like buildings and vehicles rather than more productive assets like machinery. The shortage of skilled labour coupled with the lack of bankruptcy protection and land property rights led firms to lower investment. These results highlight the conditions under which industrial policy could be successful.

The low productivity of capital estimates that we obtain in the first chapter requires more scrutiny. We do this in the second chapter. A vast body of literature tries to explain the paradox ranging from international capital market imperfection to human capital, infrastructure and institutional problems that impede capital flows from rich to poor countries. The majority of the studies that explain the paradox are cross country macro studies that assume shared technology and don't allow for firm heterogeneity in the analysis. This would result in wrong inference about the productivity of capital. There is little firm level evidence from the side of developing countries that shows the effect of human capital and infrastructure on productivity of capital. This chapter attempted to fill this gap. We take the productivity estimates from the first chapter and construct firm and year marginal productivity estimates. We then used this as an dependent variable to estimate the effect of exogenous changes in human capital, power and road infrastructure. It is reasonable to think that the firms' consumption of skilled labour, power and transport could be endogenously determined in the model. We use instrumental variables regression to address this possible source of bias. For skilled labour we use regional supply of professionals and technical employees as an instrument. This instrument is both valid and could be excluded especially for the smaller firms. For power we use the difference in adjusted and unadjusted night lights satellite data the would effectively measure variations in power supply (outages). For roads we use the road density of the region weighted by the variance in land elevation to instrument for transport cost. We assume here that firms in locations with high variance in elevation benefit from road construction more than firms located in places where the road is relatively plain. We find that all these three variable have significant positive effects on the productivity of capital. There are issues that are open for further study. The effect of skilled labour mobility and agglomeration in enhancing productivity requires a better understanding to complete the story.

In the third chapter we present an approach to measuring gender pay inequality

using the ratio of women to men labour share in income. This measure is comparable across country and time as it uses internationally comparable labour and national accounts data. The measure accounts for labour share of the self employed by adjusting their labour share by hours of work. To construct the measure we assume that hourly wages of employed and self employed are the same. This assumption would only bias the estimates if hourly wages for men and women are disproportionately different among the employed and self employed. We find that although gender pay inequality has been declining there is still a substantial gap. This gap is expected to rise as population grows since growth in population is concentrated in regions of the world where the gap is high. We use this measure to undertake a causal analysis on gender pay inequality. We estimate the causal effect of income on gender pay inequality. We find that in many middle income countries income have to triple to achieve equality from a labour share ratio of 0.4. We find little evidence of the importance of democracy and women political empowerment. Further we find that trade liberalization improves women's status while financial liberalization has the opposite effect.

All in all we find that capital is less productivity in developing countries but if human capital, power and roads develop it will become more productive. There is no guarantee that typical industrial policy of cheap loan and tax incentives works in a developing country setting where entry could offset the growth in total factor productivity. Developing countries have scarce budget resources that need to be well allocated. Careful analysis is required before engaging in typical industrial policy measures. Although improving, gender pay inequality is still substantial especially in less developed countries. However, improvements in income and trade liberalization will help reduce the gender pay gap.

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APPENDIX

Chapter 2

A.0.1 Additional Tables

A.0.2 Chapter 2: Further Examples of Industrial Policy in Sub-Saharan Africa

Tab. .6: Industrial Policy in Sub-Saharan Africa

Country	Description
Botswana	**National:** Policy aimed at enhancing productivity through highly skilled labour, export orientation and attraction of FDI. **Trade:** Customs Duty rebates on raw materials, tariff protection of infant industries and concessional import duty rebate and low tax rates. **Sectoral:** Motor Industry prioritized. Also textiles, foods and beverages benefited from support. **Other:** FDI attraction through tax incentives, human development, enterprise development and R&D support.
Cameroon	**National:** Guided by 5 year plans from 1961-1991 that focus on both import substitution and export promotion. **Trade:** Free trade zones where 80 % of production is exported. Part of the Central African Economic and Monetary Community that guides the tariff rates. **Sectoral:** Textiles, wood, energy, some cereals, cocoa, coffee, shipbuilding, ICT and pharmaceuticals received exemption from personal income tax. **Other:** FDI attraction through Investment promotion and infrastructure development.
Ethiopia	**National:** Industrial Development Strategy in 2002 focussed on Agricultural development led industrialization. **Trade:** Customs duty rebates and Export promotion measures. **Sectoral:** Meat, Textile, Construction and Agro-industry benefited from technology, financial and human capital support. **Other:** Attraction of FDI through various incentives including tax exemptions.

Ghana	**National:** Broad Growth and Poverty Reduction strategy aimed at competitiveness of private sector, human resource development and public sector reform. **Trade:** Higher tariff rates for more processed goods like textile, apparel, furniture and beverage. Part of ECOWAS customs union. **Sectoral:** ICT is a big priority. Others include biotechnology, cassava, textiles, palm oil and salt. **Other:** Established Institute of Industrial Research, FDI attracting through tax holiday (also depending on location).
Kenya	**National:** 1996 Policy: "Industrial Transformation to the Year 2020" focussing on export orientation. **Trade:** Export Processing Zones and Export promotion council, duty remission facility. Part of EAC FTA. Firms in these zones benefit from tax holiday. **Sectoral:** Agro-industries, textile, coffee, tea, construction. **Other:** Investment Authority to attract FDI through tax holiday, Industrial Research and Development Institute.
Rwanda	**National:** Included in three programs , Growth for Jobs and Exports, Vision 2020 and Governance focussing on infrastructure, reducing cost of doing business, promoting innovation and financial sector development. **Trade:** Higher Duty on more processed goods. Part of the EAC FTA that guides Duty rates. **Sectoral:** Information and Communication Technology supported through human capital, infrastructure. Coffee and tea also received support. **Other:** Rwanda investment and export promotion agency, one of the most open FDI regimes through exemption of corporate income tax.

South Africa **National:** Included in the "Accelerated and Shared Growth Initiative" focusing on manufacturing exports. This is Complemented by National Industrial Policy Framework. **Trade:** Export marketing and investment assistance, export credit incentive, export credit insurance and customs duty refunds. **Sectoral:** Capital equipment, transport equipment, automotive assembly, chemicals, plastics and pharmaceuticals, textile and footwear received support. **Other:** Government supports science and technology research, assistance on global value chain, clusters and efficiency.

Uganda **National:** National industrial policy included in "Medium Term Competitiveness Strategies" with the objectives of improving business environment. **Trade:** Fixed duty drawback scheme for exports. Member of EAC FTA that guides tariff bands. **Sectoral:** Promotion of linkages between ICT, construction, textile, agro processing and energy. **Other:** Infrastructure, financial sector, institutional and human development are part of the broader strategy. FDI attraction prioritized through tax exemptions.

A.0.3 Chapter 2: Specific Sector Support

PASDEP prioritised industrial development in four sectors, and these sectors received support from the government to achieve more non-agricultural employment, investment and production. These sectors are the textile and garment sector; meat and leather producers; agro-industry, and the construction industry. The government has implemented specific measures in support of these industries since 2003/04. These sectors were chosen for their direct linkages to the agricultural sector, labour intensiveness and export potential. These priority sectors have been subject to several benchmarking exercises and the establishment of industry-wide targets. Notable targets in PASDEP were that by the end of 2009/10 the export earnings from the textile sector would reach USD 500 million as a result of investment in the sector worth USD 1.6 billion. The majority of the additional investment was planned to come from the private sector. However, the government also planned to invest jointly with foreign investors. For the meat and leather industries it was envisaged for that export

Tab. .1: Alternative Estimates of the Effects of the Policy on Productivity

	(1) OP	(2) OP	(3) OP	(4) OP
τ_0: Post-2002	-0.04	-0.03	7.16***	-0.51**
	(0.16)	(0.16)	(0.68)	(0.24)
τ_1: Sectoral Treatment	0.24	0.23	0.24	0.27
	(0.15)	(0.15)	(0.16)	(0.17)
τ_2: Geographic Treatment	-0.09	-0.09	-0.10	-0.34
	(0.12)	(0.12)	(0.29)	(0.23)
τ_3: Total Treatment	-0.00	-0.03	0.04	0.15
	(0.20)	(0.20)	(0.24)	(0.25)
$Compet_{ts}$	-0.43	-0.43	-0.45	-0.49
	(0.33)	(0.33)	(0.34)	(0.35)
$Divers_{it}$	1.12***	1.13***	1.12***	1.00***
	(0.35)	(0.35)	(0.35)	(0.37)
Age	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Government Ownership	0.28*	0.27*	0.32**	0.31*
	(0.16)	(0.16)	(0.16)	(0.16)
Year Effects	Yes	Yes	Yes	Yes
Geography Fixed Effects	No	Region	Region × Year	Zone
N	6122	6122	6122	5564

Notes as for Table 2.4.

Tab. .2: Effects on Productivity by Treated Sector

	(1) Textiles	(2) MLP	(3) AgroIndustry	(4) Construction
τ_0: Post-2002	-0.13	-0.07	0.50**	-0.01
	(0.16)	(0.22)	(0.22)	(0.32)
τ_1: Sectoral Treatment	-0.00	-0.20	-0.22	-0.08
	(0.24)	(0.25)	(0.25)	(0.36)
τ_2: Geographic Treatment	0.04	0.05	0.01	0.29
	(0.33)	(0.27)	(0.30)	(0.41)
τ_3: Total Treatment	-0.40	-0.59	-0.18	-0.29
	(0.56)	(0.45)	(0.42)	(0.56)
Age	0.00***	-0.00	-0.01**	0.01
	(0.00)	(0.01)	(0.01)	(0.01)
Government Ownership	0.14	0.29	0.22	0.67*
	(0.30)	(0.37)	(0.25)	(0.40)
$Compet_{ts}$	-1.34	-0.40	-1.15**	0.02
	(0.85)	(1.42)	(0.53)	(0.61)
$Divers_{it}$	0.63	2.89**	0.91*	1.56
	(0.90)	(1.33)	(0.50)	(1.09)
N	576	568	2098	969

Notes as for Table 2.4.

Tab. .3: Effects on Book Capital by Treated Sector

	(1) Textiles	(2) MLP	(3) AgroIndustry	(4) Construction
τ_0: Post-2002	0.32	0.04	0.11	0.13
	(0.35)	(0.12)	(0.11)	(0.29)
τ_1: Sectoral Treatment	0.21	0.58***	0.47**	0.57
	(0.40)	(0.15)	(0.20)	(0.39)
τ_2: Geographic Treatment	-0.88**	0.31*	-0.57**	-0.74
	(0.42)	(0.16)	(0.29)	(0.53)
τ_3: Total Treatment	0.86	-0.54*	0.61	0.66
	(0.68)	(0.28)	(0.42)	(0.83)
Age	-0.00	0.01	-0.01	-0.03
	(0.00)	(0.01)	(0.01)	(0.02)
(log)Prod. Labour	0.11	0.39***	0.43***	0.19*
	(0.10)	(0.11)	(0.07)	(0.11)
Government Ownership	-0.67**	-1.18***	-1.07***	-1.47***
	(0.29)	(0.27)	(0.28)	(0.48)
$Compet_{ts}$	1.21	-0.98	0.19	-0.97
	(1.27)	(1.52)	(0.58)	(0.60)
N	623	610	2240	1113

Notes as for Table 2.5.

Tab. .4: Effects on Machinery by Treated Sector

	(1) Textiles	(2) MLP	(3) AgroIndustry	(4) Construction
τ_0: Post-2002	0.02	-0.01	-0.01	-0.01
	(0.04)	(0.02)	(0.02)	(0.04)
τ_1: Sectoral Treatment	-0.25***	-0.19***	-0.18***	-0.17***
	(0.05)	(0.04)	(0.02)	(0.05)
τ_2: Geographic Treatment	-0.03	0.03	0.06**	0.03
	(0.06)	(0.04)	(0.03)	(0.05)
τ_3: Total Treatment	0.04	0.00	-0.03	-0.01
	(0.09)	(0.06)	(0.04)	(0.07)
$Compet_{ts}$	-0.18	0.42***	0.06	0.18***
	(0.15)	(0.13)	(0.05)	(0.04)
Age	-0.00	0.00	0.00	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)
Government Ownership	-0.06*	0.05	0.00	-0.01
	(0.03)	(0.05)	(0.03)	(0.06)
N	616	605	2199	1104

Notes as for Table 2.5.

Tab. .5: Effects on Employment by Treated Sector

	(1) Textiles	(2) MLP	(3) AgroIndustry	(4) Construction
τ_0: Post-2002	-0.22***	-0.06	0.01	0.16
	(0.07)	(0.11)	(0.05)	(0.11)
τ_1: Sectoral Treatment	0.18*	0.01	0.02	0.00
	(0.11)	(0.12)	(0.07)	(0.12)
τ_2: Geographic Treatment	0.13	-0.04	-0.08	-0.13
	(0.10)	(0.12)	(0.08)	(0.12)
τ_3: Total Treatment	-0.21	-0.05	0.03	0.40**
	(0.18)	(0.29)	(0.12)	(0.20)
Age	0.00	-0.01	0.00	0.00
	(0.00)	(0.01)	(0.00)	(0.01)
(log) Total Book Capital	0.02	0.18**	0.06***	0.03*
	(0.02)	(0.08)	(0.01)	(0.01)
Government Ownership	0.34**	0.64***	0.48***	0.74***
	(0.15)	(0.17)	(0.08)	(0.28)
$Compet_{ts}$	-0.87*	-0.25	-0.72***	0.18
	(0.47)	(0.55)	(0.19)	(0.20)
N	623	610	2240	1113

Notes as for Table 2.5.

earning would increase to USD 178 million by establishing 74 firms by 2009/10. These targets highlight the continuing strong role of the state envisaged during the PASDEP period. To achieve these specific targets a host of measures have been taken related to training, input market interventions, establishing sector development institutes, public private partnerships and the scaling up of sectoral pilot projects.

All four sectors were given priority access to foreign currency. As discussed in the main text, they also all had access to concessionary loans via The Development Bank of Ethiopia, a state owned bank established facilitate investment with loans up to 70 percent of the initial capital to private sector firms investing in the four treated sectors. Sector specific support included:

- **Textiles:** The government started textile engineering training program in one of the government universities (Bahirdar University). The first class graduated in 2002. In 2010 the government established the Ethiopian Textile Development Institute to organize all the support in one institution. The institute supports existing firms and entrants in the sector on selection of technology, negotiation, construction, erection and commissioning. It also

provides practical training on technology and marketing.

- **Leather and Leather Products:** Additional export support via inclusion in the Prime Minister's Committee to Promote Exports. Also, similarly to the support provided to the textile sector, the Ethiopian Leather Industry Development Institute was established in 2010.
- **Agro-processing:** Firms in the Agro-industry sector have access to cheaper leases for land.
- **Construction:** Other than the concessionary loans and priority access to foreign exchange the construction sector received little other specific support.

A.0.4 Chapter 2: The Number of Firms by Industrial Classification

Tab. .7: Number of Firms in 1996 and 2010 in each ISIC Category

ISIC Classification	1996	2010	Treatment
1511 Production, processing and preserving of meat, fruit and veg	6	9	Treated (Agro)
1514 Manufacture of edible oil	25	31	Treated(Agro)
1520 Manufacture of dairy products	1	20	Treated(Agro)
1531 Manufacture of flour	17	154	Treated(Agro)
1533 Manufacture of animal feed	2	6	Treated(Agro)
1541 Manufacture of bakery	63	142	Treated(Agro)
1542 Manufacture of sugar and confectionary	5	17	Treated(Agro)
1544 Manufacture of pasta and macaroni	3	13	Treated(Agro)
1549 Manufacture of food NEC	4	8	Treated(Agro)
1551 Distilling rectifying and blending of spirit	6	12	Treated(Agro)
1552 Manufacture of wine	1	1	Treated(Agro)
1553 Malt liquors and malt	5	7	Treated(Agro)
1554 Manufacture of soft drinks	6	21	Not Treated
1600 Manufacture of tobacco	1	1	Not Treated

ISIC Classification	1996	2010	Treatment
1710 Spinning , weaving and finishing	18	28	Treated(Textile)
1723 Manufacture of cordage rope and twine	3	1	Treated(Textile)
1730 Knitting mills	9	0	Treated(Textile)
1810 Manufacture of wearing apparel except fur	23	40	Treated(Textile)
1910 Tanning and dressing of leather	8	27	Treated(Leather)
1920 Manufacture of footwear	50	66	Treated(Leather)
2000 Manufacture wood and wood products	25	41	Treated(Agro)
2100 Manufacture of paper and paper products	5	17	Treated(Agro)
2200 Publishing and printing services	27	65	Not Treated
2411 Manufacture of basic chemicals except fertilizers	2	19	Not Treated
2422 Manufacture of paints varnishes	5	8	Not Treated
2423 Manufacture of pharmaceutical, medicinal	1	9	Not Treated
2424 Manufacture of soap detergents, perfumes..	20	33	Not Treated
2429 Manufacture of chemical products NEC	3	4	Not Treated
2510 Manufacture of rubber	4	3	Not Treated
2520 Manufacture of plastics	10	107	Not Treated
2610 Manufacture of glass and glass products	2	2	Not Treated
2693 Manufacture of structural clay products	7	4	Not Treated
2694 Manufacture of cement,lime and plaster	6	20	Treated(Constr.)
2695 Manufacture of articles of concrete, cement	62	223	Treated(Constr.)
2699 Manufacture of non-metallic NEC	3	136	Not Treated

ISIC Classification	1996	2010	Treatment
2710 Manufacture of basic iron and steel	1	28	Not Treated
2811 Manufacture of structural metal products	27	99	Treated(Constr.)
2892 Manufacture of cutlery hand tools	0	6	Not Treated
2893 Manufacture of other fabricated metal products	4	3	Not Treated
2899 Manufacture of pumps,compressors, valves and taps	5	8	Not Treated
2914 Manufacture of ovens	5	12	Not Treated
2925 Manufacture of other general purpose machinery	6	1	Not Treated
3140 Manufacture of batteries	0	1	Not Treated
3420 Manufacture of bodies for motor vehicles	7	8	Not Treated
3430 Manufacture of parts and accessaries	1	1	Not Treated
3610 Manufacture of furniture	62	227	Not Treated

Chapter 3

A.0.5 Calculating the Variance of Night Light Data

We consider the variance of the brightness of nightlights in a given place. Each observation $i \in 1, \ldots, T$ has a latent brightness given by $y_i \in \mathbb{R}_+$ but is only observed (by satelite) if the power is on as captured by $c_i \in 0, 1$. Then the observed brighness is $x_i = c_i y_i$. The variance of brightness is then:

$$Var(x_i) = Var(c_i y_i) = Var(c_i)Var(y_i) + E[y_i]^2 Var(c_i) + E[(c_i)]^2 Var(y_i)$$

(See below)

Define, Unadjusted or stable average visible:

$$U = \frac{\sum_i y_i | c = 1}{N_{c=1}}$$

Define, Adjusted or Average_x_pct:

$$A = \frac{\sum_i y_i c_i}{N}$$

:

Then $\frac{N - N_c}{N} = Pr(c = 0)$, and $U/A = N/N_C = \gamma$. Thus we can write:

$$Var(x_i) = Var(c_i y_i) = \frac{\gamma - 1}{\gamma} N_C Var(y_i) + E[y_i]^2 \frac{\gamma - 1}{\gamma} N_C + E[1 - \frac{\gamma - 1}{\gamma}]^2 Var(y_i)$$

.

But, we cannot use this as we do not observe $Var(y_i)$, or specifically $E[y_i^2]$. Instead:

$$
\begin{aligned}
\sum x_i = \sum c_i y_i &= \sum (y_i | c_i = 1) + \sum (y_i | c_i = 0) \\
\sum x_i &= N\overline{x} \\
\sum x_i - \sum (y_i | c_i = 1) &= \sum (y_i | c_i = 0) \\
N\overline{x} - N_c\overline{y} &= (N - N_c)\overline{y} \\
\overline{x} - \frac{N_c \overline{y}}{N} &= \frac{(N - N_c}{N}\overline{y}) \\
A - U &= Pr(c_i = 0)Y \qquad (*)
\end{aligned}
$$

The last line, A, establishes that the difference between the adjusted and the unadjusted is equal to the reliability of the electricity supply scaled by the average brightness. But, one might be concerned that somehow that this scaling introduces additional complications.

Thus we can also consider the unscaled measure which is simply:

$$
Pr(c_i = 0) = \frac{N - N_c}{N} \qquad (**)
$$

Which is just the proportion of observations which are not observed.

A.0.6 Chapter 3: Data Processing

Geographic Data

The large and medium scale manufacturing survey includes variables pertaining to human capital, power use and transport costs. Using these to determine their effect on marginal productivity of capital could result in bias as they could be endogenous determined. Thus we utilize exogenous geographic variations of night lights and road network (augmented by elevation).

The night lights data are obtained from Earth Observation Group *Version 4 DMSP-OLS Nighttime Lights Time Series* (n.d.)in raster format. The data range from 1992 to 2013 with multiple observations for some years. In those years two satellites collected the data. There are two types of night light data. The first is cloud free composite made using archived smooth resolution data. The second

type adjusts this data by the percent frequency of light detection. This adjustment accounts for the persistence of light.

We follow Lowe (2014) in processing these data. We take both types of night lights data and the difference between them would indicate the exogenous variation in lighting. The aim is to measure year-wereda combination of night light for the period 1996-2012. In order to measure that we need the lights data in raster format to be joined with the administrative boundaries of the woreda in polygon format. This in turn requires the raster data to be an integer. In order not to lose the decimal places we multiply the data values by 1000 and then convert the data into integer. We then convert the raster data to polygon to combine it with the woreda(polygon) and road network(polyline). For the years in which two satellites collected data we take averages of the two rasters before converting them to the polygon format.

The raster data for elevation are obtained from *DIVA-GIS, Spatial Data Download* (n.d.) . We combine We use the same procedure as above to convert the raster data to polygon format.

Professional and Technical Labour Data

As indicated above the manufacturing survey includes variables pertaining to the occupation of employees. We have the number of technical professional employees. We could use this to represent human capital in the estimation. However, estimates could be biased as employment could itself be endogenously determined. As mentioned above we obtained the number of technical and professional employees from the urban employment and unemployment survey conducted by the Central Statistics Agency of Ethiopia.

The survey is nationally representative for the urban areas of the country.

A.1 Chapter 4

A.1.1 Labor Share Data

The dataset is a country level panel taken from three major sources International labor Organization (ILO) and United Nations System of National Accounts (SNA) and United Nations Industrial Development Organization(UNIDO). We use the SNA to reproduce and extend the Gollin (2002) labor share calculations. We use the ILO and UNIDO data to calculate the hours of work adjusted labor share of the total economy and the manufacturing sector. All of these variables are disaggregated by gender except wages and salaries which, for the are substituted by earning per month data from ILO.

A.1.2 Chapter 4: Construction of Instrumental Variables

The analysis of whether economic growth and democratization lead to improvements in gender equality, and how rapidly, in Section 4.3 employs four instrumental variables. The first is a gravity-weighted trade shock measure. The second and third measure terms of trade shocks via changes in the prices of commodity imports and exports for agricultural and mineral commodities respectively. The final instrument proxies for financial crises using IMF or World-Bank crisis-interventions. We now outline the construction of these variables in turn.

Gravity

We estimate a standard Trade-Gravity model of the form:

$$T_{ijt} = \alpha_0 Y_{it}^{\alpha_1} Y_{jt}^{\alpha_2} D_{ijt}^{\alpha_3} e^{\theta_i d_i + \theta_j d_j} \tag{.1}$$

Where Y_{it} and Y_{ij} are the GDPs of countries i and j in year t. D_{ijt} is a vector containing measures of the 'distance', broadly conceived, between i and j in year t. In our case this includes whether the countries are contiguous, share a common language, colonial history, currently colonial relationship, common legal system, a common currency, are members of the same regional trade agreement,

and whether the origin or destination country are members of GATT, and their respective gdp per capitas. d_i and d_j are fixed-effects for the origin and destination countries respectively. These capture other, unmeasured, country characteristics that may cause them to export a particularly large or small amount.

Using the data used by Head et al. (2010) we estimate (.1) using the Poisson pseudo Maximum Likelihood estimator proposed by Silva and Tenreyro (2006). We then obtain predicted flows for each pair of countries for each year. Our instrument is then:

$$S_{it} = \sum_j \widehat{T_{ijt}} \times \Delta Y_{jt} \tag{.2}$$

Commodities

Our commodity price shock instruments, follow the approach of Deaton and Miller (1996) are given by the product of changes in the global price for each commodity in a given year multiplied by the share of that commodity in a country's trade in a fixed year. By fixing a year, we are able to rule out changes in the composition of the economy in response to price shocks. We use the year 2000 as our fixed year.

$$C_{it} = \sum_c \Delta P_{ct} \times X_{c,2000} \tag{.3}$$

The data on commodity prices and trade are taken from COMTRADE.

Crises

Our crisis instrument, is based on the data of Boockmann and Dreher (2003) and Dreher (2006), and is defined as the total number of World Bank projects and IMF Arrangements agreed or in effect in a particular year.

A.1.3 Chapter 4: Additional Tables

Tab. A.1.1: Effects of Income and Democratization on labor Market Gender Inequality, Alternative Instruments

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(log) GDP per Capita	0.127**	0.173**	0.654	0.564	0.121*	0.149	0.127**	0.272*	0.297*
	(0.030)	(0.029)	(0.231)	(0.161)	(0.080)	(0.227)	(0.030)	(0.056)	(0.064)
$\rho_{i,t-1}$	0.457***	0.442***	0.308*	0.312**	0.459***	0.452***	0.457***	0.410***	0.416***
	(0.000)	(0.000)	(0.089)	(0.036)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Women's Political Empowerment	0.042	0.062	0.247	0.216	0.040	0.050	0.042	0.101	0.109
	(0.170)	(0.113)	(0.272)	(0.199)	(0.234)	(0.321)	(0.170)	(0.104)	(0.115)
Estimator	IV	IV	IV	IV	IV	IV	IV	IV	IV
Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Instruments	Gravity, Commodities, Crises	Gravity, Commodities, Crises	Gravity	Lag Gravity	Commodities	Crises	Commodities, Crises	Lag Gravity, Crises	Gravity, Crises
Observations	1233	1158	1116	1158	1233	1233	1233	1158	1116
Kleibergen-Paap p-value	0.00	0.00	0.22	0.12	0.00	0.01	0.00	0.03	0.05
Hansen J p-value	0.55	0.26			0.27		0.55	0.25	0.26

Specifications are all identical except for different instrument sets. *Commodities* refers to the agricultural and mineral commodity shock instruments. *Gravity* refers to the gravity-weighted trade shock instrument. *Lag Gravity* refers to the first-lag of *Gravity*. *Crises* refers to the IMF or World-Bank intervention instrument. Keibergen-Paap is measure of under-identification while Hanson J tests over-identification for the IV estimates. All other details as for Table 4.1.

Tab. A.1.2: Effects of Income and Democratization on labor Market Gender Inequality, Other Measures of Democracy and Female Empowerment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(log) GDP per Capita	0.174**	0.137**	0.139**	0.161**	0.132**	0.131**	0.130**	0.132**	0.083	0.090
	(0.027)	(0.011)	(0.011)	(0.022)	(0.011)	(0.011)	(0.011)	(0.011)	(0.387)	(0.336)
$\rho_{i,t-1}$	0.442***	0.454***	0.452***	0.443***	0.454***	0.453***	0.454***	0.454***	0.247***	0.249***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Women's Political Empowerment	0.059									
	(0.119)									
Electoral Democracy	0.003									
	(0.882)									
Women's civil liberties		0.026								
		(0.178)								
Women's civil society participation			0.014							
			(0.351)							
Women's political participation				0.018						
				(0.326)						
Egalitarian democracy					0.008					
					(0.673)					
Deliberative democracy						0.001				
						(0.929)				
Participatory democracy							0.002			
							(0.909)			
Liberal democracy								0.005		
								(0.733)		
Share Women Lower House									0.000	
									(0.443)	
Share Women Upper House										0.000
										(0.557)
Estimator	IV	IV	IV	IV	IV	IV	IV	IV	IV	IV
Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1158	1184	1184	1158	1184	1184	1184	1184	625	617
Kleibergen-Paap p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hansen J p-value	0.27	0.26	0.27	0.33	0.30	0.30	0.30	0.30	0.09	0.08

Columns 1-8 report alternative dimensions of democracy contained in the V-Dem data ((Coppedge et al., 2016) Columns 9 and 10 report the proportion of seats in the lower and upper houses of the legislature held by women. These data are taken from the Inter-Parliamentary Union http://www.ipu.org/wmn-e/world.htm. Keibergen-Paap is measure of under-identification while Hanson J tests over-identification for the IV estimates. All other details as for Table 4.1.

Tab. A.1.3: Effects of Income and Democratization on labor Market Gender Inequality, Assuming Different Values of ϕ

	$\rho = 0$	$\rho = 0.25$	$\rho = 0.5$	$\rho = 0.75$	$\rho = 1$	$\rho = 0$	$\rho = 0.25$	$\rho = 0.5$	$\rho = 0.75$	$\rho = 1$
(log) GDP per Capita	0.119***	0.088***	0.057***	0.026***	0.005	0.348***	0.249***	0.150**	0.051	−0.048
	(0.000)	(0.000)	(0.000)	(0.000)	(0.424)	(0.001)	(0.002)	(0.020)	(0.401)	(0.504)
Women's Political Empowerment	−0.010	−0.004	0.002	0.009	0.015	0.118**	0.086**	0.055	0.023	−0.008
	(0.670)	(0.843)	(0.882)	(0.563)	(0.352)	(0.030)	(0.045)	(0.111)	(0.451)	(0.815)
Estimator	IV	IV	IV	IV	IV	IV	IV	IV	IV	IV
Trends	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Observations	1158	1158	1158	1158	1158	1158	1158	1158	1158	1158

Each column reports a different assumed value of the AR(1) coefficient ϕ. Columns 1-5 do not include country specific trends. Columns 6-10 do. Keibergen-Paap is measure of under-identification while Hanson J tests over-identification for the IV estimates. All other details as for Table 4.1.

Tab. A.1.4: Effects of Income and Democratization on labor Market Gender Inequality, Other Measures of Globalization

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(log) GDP per Capita	0.124***	0.123**	0.111***	0.117**	0.123**	0.127***	0.117**	0.128***
	(0.009)	(0.010)	(0.010)	(0.018)	(0.010)	(0.009)	(0.017)	(0.008)
$\rho_{i,t-1}$	0.445***	0.450***	0.440***	0.444***	0.443***	0.442***	0.450***	0.447***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
economic globalization	−0.000							
	(0.343)							
actual flows		0.000**						
		(0.033)						
restrictions			−0.000***					
			(0.004)					
social globalization				−0.000				
				(0.250)				
personal contact					−0.001*			
					(0.059)			
information flows						−0.000*		
						(0.097)		
cultural proximity							−0.000	
							(0.842)	
political globalization								−0.000
								(0.697)
Estimator	IV	IV	IV	IV	IV	IV	IV	IV
Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1229	1229	1229	1229	1229	1229	1229	1229
Kleibergen-Paap p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hansen J p-value	0.29	0.17	0.39	0.30	0.14	0.19	0.24	0.25

All variables are sub-components of the KOF index (Dreher et al., 2008) in Table 4.2. Keibergen-Paap is measure of under-identification while Hanson J tests over-identification for the IV estimates. All other details as for Table 4.1.

Tab. A.1.5: Effects of Income and Democratization on labor Market Gender Inequality, Other Measures of Financial Openness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(log) GDP per Capita	0.131*	0.107	0.127*	0.131*	0.146**	0.135*	0.128*	0.148**	0.139**
	(0.068)	(0.114)	(0.081)	(0.059)	(0.037)	(0.053)	(0.071)	(0.038)	(0.049)
$\rho_{i,t-1}$	0.445***	0.492***	0.446***	0.444***	0.431***	0.445***	0.440***	0.429***	0.439***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Directed credit/reserve requirements	0.000								
	(0.864)								
Aggregate Credit Ceilings		0.002							
		(0.555)							
Credit Controls			0.001						
			(0.600)						
Interest rate controls				−0.000					
				(0.782)					
Entry barriers/pro-competition measures					−0.003**				
					(0.014)				
Banking Supervision						0.001			
						(0.644)			
Privatization							−0.004*		
							(0.078)		
International capital flows								−0.003***	
								(0.004)	
Security Markets									−0.002
									(0.258)
Estimator	IV	IV	IV	IV	IV	IV	IV	IV	IV
Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	967	565	967	967	967	967	967	967	967
Kleibergen-Paap p-value	0.03	0.02	0.03	0.02	0.01	0.01	0.02	0.01	0.02
Hansen J p-value	0.25	0.02	0.22	0.29	0.44	0.25	0.18	0.55	0.34

All variables are sub-components of the Financial Reform index (Abiad et al., 2010) in Table 4.2. Keibergen-Paap is measure of under-identification while Hanson J tests over-identification for the IV estimates. All other details as for Table 4.1.

Tab. A.1.6: Effects of Income and Democratization on labor Market Gender Inequality, Other Demographic Controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(log) GDP per Capita	−0.523	0.124**	0.158**	0.177**	0.180*	0.124**	0.100*	0.158**	0.177**
	(0.219)	(0.011)	(0.021)	(0.035)	(0.057)	(0.011)	(0.051)	(0.021)	(0.035)
(log) GDP per Capita^2	0.045*								
	(0.099)								
$\rho_{i,t-1}$	0.401***	0.449***	0.429***	0.428***	0.418***	0.449***	0.466***	0.429***	0.428***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Women's Political Empowerment	0.117**								
	(0.045)								
Crude Birth Rate		−0.001*							
		(0.064)							
Secondary Enrollment Ratio			−0.000						
			(0.676)						
Tertiary Enrollment Ratio				−0.000**					
				(0.021)					
Expected Years of Schooling Ratio					−0.126**				
					(0.022)				
Life Expectancy Ratio						0.093			
						(0.247)			
Primary Enrollment Loss Ratio							−0.007		
							(0.857)		
Secondary Enrollment Loss Ratio								−0.010	
								(0.676)	
Tertiary Enrollment Loss Ratio									−0.030**
									(0.021)
Estimator	IV	IV	IV	IV	IV	IV	IV	IV	IV
Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1158	1241	984	927	815	1241	1087	984	927
Kleibergen-Paap p-value	0.01	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.04
Hansen J p-value	0.98	0.16	0.19	0.12	0.03	0.18	0.34	0.19	0.12

Crude Birth Rate is the Crude Birth Rate per $1,000$ people. *Secondary (Tertiary) Enrollment Ratio* is the ratio of girls to boys enrolling in secondary (tertiary) education. *Expected Years of Schooling Ratio* is the ratio of women's to men's expected years of schooling. *Life Expectancy Ratio* is the ratio of women's to men's life expectancies. *Primary Enrollment Loss Ratio* is the ratio of the percentage of girls to the percentage of boys who enroll in primary education but fail to complete it. *Secondary (Tertiary) Enrollment Loss Ratio* is the ratio of the percentage of girls to the percentage of boys who enroll in secondary (tertiary) education but fail to complete it. Keibergen-Paap is measure of under-identification while Hanson J tests over-identification for the IV estimates. All other details as for Table 4.1.