The Pennsylvania State University

The Graduate School

TWO ESSAYS IN INTERNATIONAL TRADE AND DEVELOPMENT

A Dissertation in

Economics

by

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

August 2021

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Abstract

This dissertation consists of two chapters on two topics in development and international trade.

In Chapter 1, I study the phenomenon of some large developing countries deviating from the expected pattern of non-agricultural informality declining with income growth. I focus on the striking case of India where informality in manufacturing fell only by 1% from 1999-00 to 2009-10 while per-capita income more than doubled. On the demand side, I find that the informal expenditure share Engel for manufactured goods is downward sloping but not log-linear, implying that the distribution of income gains matters. In particular, the Engel effect is the weakest among households at the top of the income distribution, who experienced the greatest gains in this period. On the supply side, income growth is correlated with more schooling, which is expected to aid formalization because formal firms are skill intensive. In India, while educational attainment improved, increased capital use further displaced lower skill workers from formal manufacturing firms. Consistent with these findings, I add product dualism with varying income elasticity of informal expenditure, worker heterogeneity, and capital to the conventional informality framework of heterogeneous firms asymmetrically impacted by regulations and taxes. Cheaper capital imports following trade liberalisation, a positive shock to domestic capital supply, and technological change all contribute to increased skill selectivity among formal manufacturing firms. Without these shocks, I estimate that the observed improvement in the educational composition of the manufacturing workforce would have lowered manufacturing informality by 2.7%. In addition, if income growth among the wider non-manufacturing workforce had been equally distributed instead of top-decile concentrated, I estimate that manufacturing informality would have been reduced by a total of 8.6%.

In Chapter 2, I study how introducing endogenous bankruptcy into a model of

exporting with financial constraints affects the entry of firms into foreign markets. The financial constraints and exporting literature has long modelled a fixed cost of exporting as a crucial financial obstacle to overcome, creating a theoretical link between financial constraints and export participation. Previous work (Eaton et al. (2007)), has also shown that a large fraction of new exporting firms fail to continue exporting beyond the first year. Static models of exporting with financial constraints cannot fully internalise the effect of borrowing which finances an unsuccessful export venture on a firm. In this chapter, I present a dynamic model of firms in a two country environment with external borrowing and endogenous bankruptcy. I use a panel data-set of Colombian manufacturing firms combining financial performance and export information to calibrate the model, and find that the introduction of endogenous bankruptcy significantly distorts firm entry and exit both directly and by means of precautionary effects. While the effect of endogenous bankruptcy on the fraction of firms that attempt exporting in their lifetime is modest, it delays exporting by reducing the use of credit by 65% and forcing firms to rely on their internal savings to pay the fixed cost instead. It also makes an exit from exporting in the first year more likely by making it harder for the firm to ride out shocks while remaining in the export market. By reducing the tenure of firms in the export market, endogenous bankruptcy has a substantial 6.3% effect in reducing the extensive margin of exporting in a given year.

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Acknowledgements

I am profoundly indebted to my advisor, Jonathan Eaton for his constant support, encouragement and patient guidance through the process of completing this dissertation. He gave generously of his time and knowledge, and the many keen insights he shared are an irreplaceable part of my learning experience at Penn State. Particularly as someone who lacked any significant preexisting exposure to Economics, Jonathan's sage advice was instrumental in getting me started on my research endeavours and keeping them on a fruitful path.

I would also like to sincerely thank Michael Gechter for his steadfast support, and especially for his commitment to helping me clarify and better express my ideas and findings. His guidance was invaluable in helping me successfully navigating a pandemic afflicted final year. In addition, I'm deeply grateful to James Tybout for all his encouragement through the years, and for many enriching discussions which improved my work.

My forays into research have also benefited significantly from conversations with Kala Krishna and Kim Ruhl during his time at Penn State, as well from valuable suggestions given by the many participants of the Trade and Development Reading Group. I'm also very grateful to Chloe Tergiman for kindly agreeing to serve on my committee.

I've had numerous productive and illuminating discussions with my fellow graduate students at Penn State, far too many to list them all. However I would like to especially thank Alejandra Lopez Espino and Joschka Wanner for all their inputs, for reviewing my work, and at times for just being there to listen. I would also like to express my gratitude for the exemplary support rendered by Krista Winkelblech in helping me keep abreast of all the administrative processes involved in completing this program and starting a life in a new country.

I'm also fortunate for the company of many friends at Penn State, whose warmth thawed the winters of State College. A special thanks to Maxence Valentin, Garima Singal, Meghna Bramachari, Faheem Gilani, Maria Dolores Molina, Alessandra Rizzi, Ivana Ancic, Farhod Olimov, Adam Ryan, Mengli Sha, Armela Mancellari and Paul Ko.

Finally, for their unwavering belief in me, for always being on my side, and for making it possible for me to pursue my dreams, my parents - Anna and Amma.

Dedication

To my mother Vani Arakere, and my father Chandrasekhar Belavadi

Chapter 1

Informality, Inequality and Trade: Understanding Development without Formalization

1.1 Introduction

Informality[1] is a pervasive feature of most developing countries, with a multiplicity of welfare consequences. Workers in informal firms enjoy far fewer job protections than their formal counterparts, and the informal-formal wage gap is a key part of overall wage inequality in many countries. Informal firms do not pay taxes, shrinking the government's ability to fund public goods. Moreover, not paying taxes also gives informal firms an artificial cost advantage, potentially inhibiting the expansion of the formal sector (Farrell (2004), Hsieh and Klenow (2009)). On the flip side, the informal sector possibly provides an employment buffer when the economy is impacted by shocks.

Within the ranks of developing countries, informality becomes markedly less prevalent with increased per-capita income. It disappears almost entirely in the rich countries of the world. This robust cross-country pattern, is used by La Porta and Shleifer

[1]Informal firms are defined as firms that are unregistered with the government, and informal employment is defined to be employment without social security protections. The exact nature of these social security benefits varies from country to country. The term informality is used to refer to informal employment.

(2008 & 2014)) to argue that individual countries will shed informality as they get wealthier.[2]

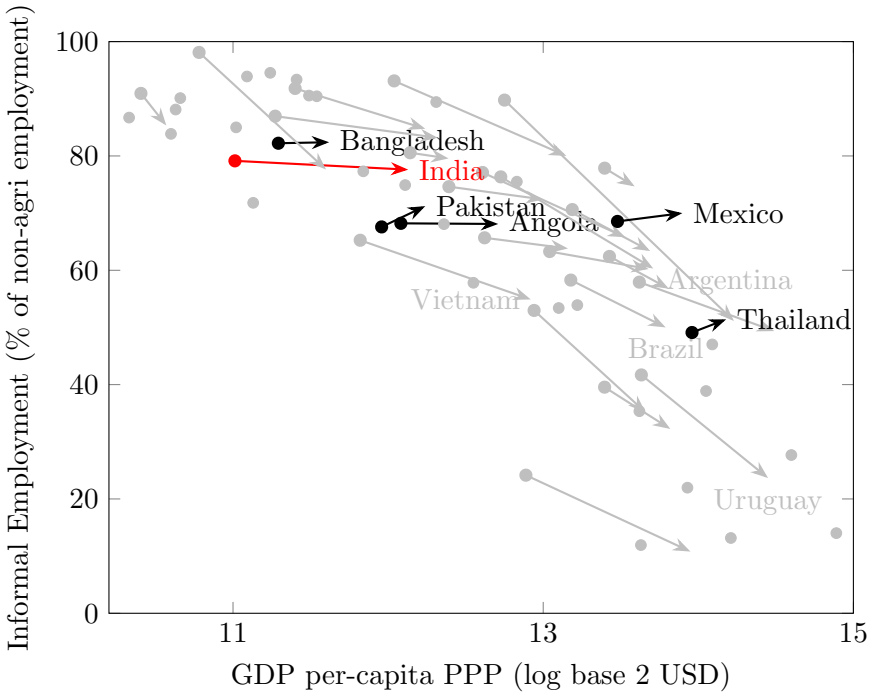


Figure 1.1: Informality, and changes in informality by country plotted against PPP GDP per-capita

Source: India - NSS Employment and Unemployment Surveys(1999-00 & 2011-12). Other countries - ILOSTAT harmonized series and Tornarolli et al. (2014). GDP per capita data from World Development Indicators.

As seen in Figure 1.1, the experience of many individual countries agrees with the cross-country pattern that income growth is accompanied by significantly lower non-agricultural informality. There are however large developing countries, particularly but not exclusively in South Asia which do not see these declines. In this paper, I investigate the reasons behind growth without formalisation in India, the largest of these countries, and one of the most profuse in its collection of high quality data. From 1999/00 to 2010/11, India's per-capita income more than doubled (Table 1.1). With

[2]Such a pattern would also be consistent with the long-held understanding in development economics that growth involves moving surplus labor from subsistence to more productive segments of the economy (Lewis (1954,1955), Kuznets (1955), Kuznets and Murphy (1966) and Harris and Todaro (1970)).

the exception of China, this represented the highest rate of income growth recorded by any G-20 economy, and it brought about barely any gain in the proportion of formal employment in manufacturing or among the broader non-agricultural workforce. With a focus on manufacturing, which grew at the same pace as the rest of the economy (maintaining a ∼16% share of GDP), I examine this incongruity. How is it that India managed to pair such large gains in per capita income with no corresponding gains in formalisation, and what does this mean for our wider understanding of the relationship between informality and income in developing countries?

Table 1.1: Informality and indicators of informality in sectors

	Manuf.	**All Non-Agri Sectors**				**GDP (PPP)**
	(1)	(2)	(3)	(4)*	(5)	(per-capita)
1999-00	77			79	77	$2009
2004-05		73	71	74	78	$2696
2009-10		78	74	77	76	$3912
2010-11	76					$4237
2011-12		79	74	77	76	$4494

(1) - Percentage of informal employment as defined by National Commission for Enterprises in the Unorganised Sector(NCEUS). Employment in unregistered enterprises plus non-permanent employment in registered enterprises

(2) - Percentage of workers with no written employment contract

(3) - Percentage of workers with none of the 3 major social security benefits (either provident fund accounts, gratuity or healthcare benefits)

(4)* - Percentage of workers with no provident fund accounts (definition of informal employment)

(5) - Percentage of workers working in unincorporated proprietary and partnership firms among those reporting a known enterprise type

All percentages are with respect to total employment in that sector or group of sectors

Sources: Annual Survey of Industries 1999-00 & 2010-11, NSS Unincorporated Non-Agricultural Enterprises Survey 1999-00 & 2010-11, NSS Employment and Unemployment Survey 1999-00, 2004-05, 2009-10, & 2011-12

Previous works point to two major mechanisms which are expected to play a part in shrinking informality with income growth. Consistent with the dual economy literature, there is now extensive multi-country evidence that informal goods behave as inferior goods[3]. As a consequence, the informal expenditure share as well as the

[3]Bachas et al. (2019) plots informal expenditure Engel curves for 31 countries across Latin

employment it sustains are expected to reduce with income. In India, I find that the informal expenditure share Engel for manufactured goods is downward sloping overall, but not in a log-linear manner. In particular, the income elasticity of informal expenditure share for manufactured goods is very small among high-income consumers whose expenditure on informal manufactured goods is near zero, and can fall no further[4]. This new insight implies that India's distribution of income gains, which have disproportionately favored the top decile, are limited in their ability to induce a demand shift away from informal manufactured goods.

The second mechanism arises from formal firms generally being more skill intensive than their informal counterparts. This suggests that higher average years of schooling seen in richer countries contributes to greater formality. Haanwinckel and Soares (2016) draws such a causal link between large-scale improvements in educational attainment, and the decline in informality in Brazil in the 2000's. Without delving explicitly into informality, Gomes and Kuehn (2017) document a positive correlation between average firm size and the fraction of the population with secondary education or above. Busso et al. (2015) finds a similar positive correlation with direct measures of skill such as literacy and numeracy. Tied with the fact that larger firms are much less likely to be informal (La Porta and Shleifer (2014)), this further suggests that improved educational attainment reduces informality.

In India, I find that formal manufacturing firms are clearly skill-selective[5] relative to their informal counterparts. In 2000, only ∼13% of the manufacturing workforce with below primary education was employed in a formal firm, while 56% of those with tertiary education were. Between 2000-2010, Barro-Lee data shows the fraction of population with below primary education falling from 44% to 33%. The educa-

America and Africa, almost all of which are negatively sloped (see Appendix A). Reilly et al. (2006) finds a similar negatively sloped Engel curve in Serbia. Bohme and Thiele (2011) look at consumption data from six West African capitals and show an income elasticity of demand that is above 1 for formal goods, and substantially below 1 for informal ones.

[4]Owing to data constraints, I do not estimate an overall informal expenditure Engel like Bachas et al. (2019). Just for specific manufactured goods which are widely produced in both formal and informal sectors. Their cross-country estimates of overall informal expenditure share elasticity shows an inverted U pattern when plotted against country incomes, which would be consistent with higher income developing countries having a larger share of the population who have transitioned out of consuming some categories of informal goods

[5]I use the terms skill intensive and skill-selective interchangeably. A firm is skill-selective if the probability of being employed in it increases with education.

tional composition of the manufacturing workforce mirrored these gains. However, a corresponding gain in the share of employment in formal manufacturing firms was not realised. The fraction of those belonging to every educational category below tertiary education who were employed in formal manufacturing firms fell, while it rose for the tertiary educated. This change accompanied a near doubling of capital intensity in formal manufacturing firms. Cheaper capital (Sen and Das (2014)), possibly aided by skill biased technical change, displaced lower skill workers from already skill intensive formal firms.

Guided by the data, I build a general equilibrium model of informality which adds product dualism with varying income elasticity of informal expenditure, worker heterogeneity, and capital to the conventional framework of heterogeneous firms asymmetrically impacted by regulations and taxes. An implication of product dualism and non-homothetic preferences is that demand for informal goods by low income workers is what sustains informal firms. In addition, I employ a non-homothetic preference setup where the income elasticity of informal expenditure share is not just non-zero (such as Comin et al. (2015)), but also variable with income (zero at high income levels, and negative at lower income levels). This utility function is taken from Armendariz (2015), and is related to a generalized CES function of the kind seen in Jung and Simonovska (2019). Workers differ in skill, and production takes place in a task based framework of the kind seen in Costinot and Vogel (2011), where firms have the choice of using either workers or capital/machines to complete any given task. Formal firms end up being skill-selective because the low complexity tasks involved in the production of their good (where low skill workers would have a comparative advantage) are performed by machines in equilibrium. Informal firms, which produce a lower quality product that involves less complex tasks, and face a higher cost of capital, use predominantly low-skill labor to produce their goods.

These features make reducing informality through policy interventions, and doing so in a manner that produces welfare gains, more complex than what is seen in most conventional models of informality. Without product dualism and worker heterogeneity, the existence of the informal sector is contingent on distortionary labor market frictions, taxes and regulations (Prado (2011), Meghir et al.(2015), Ulyssea (2018) and Dix-Carneiro et al.(2018)). Consequently, it is a source of misallocation and welfare losses, to the extent that informal firms are low productivity enterprises

surviving via tax and regulatory evasion. Dix-Carneiro et al. (2018)) in particular, finds large welfare gains to eradicating the informal sector through fines and penalties even after accounting for the informal sector's possible role as a buffer against shocks. This is driven by a reapportionment of homogeneous workers from informal to formal firms. Incorporating worker heterogeneity and formal sector skill selectivity would slow such a transition, especially for the lowest skilled workers. Adding product dualism implies that dismantling the informal sector through enforcement removes a distinct good, particularly valued by those who can't yet afford the formal good. Gains in skill and income among low skill/low wage workers become more central to reducing informality.

In this context, I perform several counterfactuals starting with trade liberalisation (India's average weighted tariffs fell from 56% in 1990 to 29% in 1999, and further to 6% by 2010). Trade liberalisation has no impact on the skill composition of the workforce, and produces real income gains which are largely restricted to high income/high skill workers. This is because only formal firms engage in exporting (and they employ higher skill workers), and cheaper imports of capital goods drive up wages for the high skill workers they are complementary to[6]. In addition to producing a muted demand shift, the increased capital use impedes the incorporation of low skill workers in formal employment. The net effect on informality is minimal, and while there is an aggregate welfare gain, it is narrowly focused. Positive capital productivity shocks have similar effects, because technological change is skill biased and the consequent real income gains favor the highest skilled workers in formal firms.

The impact of closing the difference in taxation between formal and informal manufacturing firms is highly dependent on how the revenue from taxation is used. If the additional revenue from taxing informal firms is redistributed equally[7], this helps the low income consumers who suffer the greatest real income loss from the higher price of the informal good. The income support combines with the reduced cost advantage of informal firms in lowering informality. However, if the additional tax

[6]Lower tariffs are seen to have resulted in a 62% rise in investment in foreign capital goods in India (Kandilov and Leblebicioglu (2016))

[7]Several government programs can be thought of as increasing the purchasing power of consumers over manufactured goods. These are direct income transfer programs, public works programs providing wages (called MGNREGA in India), subsidies reducing the price of other goods like food and fuel, and several public goods that save people from having to spend on a private replacement.

revenue does not benefit lower income workers, they disproportionately bear the cost of the tax as the primary consumers of informal goods without a compensating gain. The informal good gets relatively more expensive, while the formal good becomes no more affordable for them, and they suffer a welfare loss while the economy does not experience a fall in informality.

In contrast, improving the educational composition of the workforce adds to formal employment both directly and indirectly. Directly, it makes a higher fraction of the workforce eligible to work in skill-selective formal firms and improves the competitiveness of labor vis-a-vis capital. Indirectly, it effectively reduces the aggregate demand for informal goods by inducing income gains which are the greatest for low wage workers. Income gains occur among those whose skill is improved, but also among those on the margin of formal employment who benefit from lower skill-selectivity as labor displaces capital. This suggests that an important public policy measure to be used to lower informality while harnessing the welfare gain from lower misallocation and higher tax revenues without the losses, is improving the educational composition of the workforce. Doing so allows more of the workforce to transition to formal firms, and results in broad based income gains which reduces reliance on the informal good.

To estimate the full impact of the demand channel, I test the effect on manufacturing informality if India's income gains among the wider non-manufacturing workforce over the decade had been equally distributed. In other words, if the average per-capita income had grown to 2010 levels, while retaining the income distribution of 2000. I estimate that manufacturing informality would have been lower by 4.9%. To show the impact of the supply channel, I examine the outcome if improvements in the educational composition of the manufacturing workforce had occurred without increases in capital imports, domestic capital supply and technological change making capital cheaper and more productive. I find that while it would have reduced manufacturing informality by 2.7%, the higher cost and lower productivity of capital also reduce overall formal output and utility. If India had seen both income growth without increased inequality, and educational composition gains without the shocks that favored capital usage, informality in manufacturing would have fallen by 8.6%.

This paper adds to the relatively nascent literatures on informality and inequality, and informality and skill, as well as to a more developed literature on informality and trade. While the empirical evidence points to the importance of Engel effects, product

dualism and non-homotheticity in demand are rarely incorporated in any structural model of informality. In particular, the author knows of no other paper where a *variable* income elasticity of informal expenditure share plays a role in shaping how unequal income gains impact informality. While supply side factors are much more frequently analysed, most of the literature is focused on firm heterogeneity and firm compliance (Prado (2011), Ulyssea (2018)). Several of these papers incorporate rich institutional environments (Ulyssea (2010), Meghir et al. (2015), Dix-Carneiro et al. (2018)), but forgo worker heterogeneity. Of those that do incorporate worker heterogeneity (Haanwinckel and Soares (2016), Boeri et al. (2011)), no paper that author knows of incorporates a role for capital in shaping the skill selectivity of formal firms. On informality and trade, papers have found mixed or small effects of trade liberalisation on informality (Goldberg and Pavcnik (2003), Bosch et al. (2012), Paz (2014), Cruces et al. (2018), McCaig and Pavcnik (2018)). This paper finds small effects in aggregate, but via a notably different set of channels.

1.2 Data and Facts

1.2.1 Data

The enterprise data which is used in calibrating the model comes from two sources, the Annual Survey of Industries (ASI), and the National Sample Survey Organisation (NSSO). The ASI surveys firms which are registered under the Indian Factories Act of 1948 (formal firms), and reports on their operational characteristics, sales, input usage, expenses and other such metrics. This survey is conducted annually, and the 2010-11 survey for example, covered about 52,000 firms out of a total of around 120,000. The survey method is a repeated cross-section with the sample of firms changing every year. Its companion, the NSSO's "Survey of Unincorporated Non-Agricultural Enterprises" furnishes us information on the informal sector in India. Given the large fraction of informal firms that operate as family run enterprises, the NSSO's survey collects data on the nature of the firm's ownership in addition to their location, expenses, input usage and gross value addition. This survey is only done once every decade, and is done using two independently drawn samples that covered over 330,000 firms in 2010-11 (out of a total of some 17 million informal firms). We

will have to use both datasets to get a full view of the establishments in India. We will pair the 1999-2000 Non-Agricultural Enterprises survey from the NSSO's 55th round, with the same year's ASI survey in order to get a view from the beginning of the observation period, and we will pair the 2010-11 survey from the NSSO's 67th round with its ASI counterpart to represent the end of the observation period.

The ASI's survey data is largely composed of manufacturing firms ($> 93\%$), while only a third of the firms in the NSSO's survey engage in manufacturing activities. To even it out, and because it reflects the focus of this paper, I will only select the manufacturing firms from both surveys. To get moments reflective of the population, I use the sampling weights that are supplied with both of these surveys. In addition to the Survey of Unincorporated Non-Agricultural Enterprises at either end of the decade, I will also use data from NSSO's 2005-06 Survey of Unorganised Manufacturing. This mid decade survey, focuses exclusively on informal manufacturing enterprises. This survey, has the additional benefit of providing the prices of goods produced by informal firms, which the Survey of Unincorporated Non-Agricultural Enterprises does not.

Data on the educational attainment of workers is given by the NSSO's Employment and Unemployment Survey (EUS). We use the 55th round (1999-00) and the 66th round (2009-10) of the EUS to provide evidence in support of our model, parallel to the enterprise surveys. The EUS from 2009-10 is one year offset from the enterprise surveys for 2010-11, owing to the lack of availability of both for any one of the two years. This is India's version of a labor force survey, and in addition to employment and unemployment, collects data on various socio-economic metrics including educational particulars. Information collected from the workers about the type of enterprises in which they were engaged, and the conditions of employment is used to interpret whether the firm of employment is formal or informal. There is no way of combining this data with the two previously noted enterprise surveys, because they use independent samples. However, I do observe the educational composition of the workforce used by formal and informal manufacturing firms in each sector and region.

Data on household consumption comes from the NSSO's Household Consumer Expenditure survey. Once again, I use the 55th round (1999-00) and the 66th round (2009-10). This survey measures the expenditure of the sampled households under

various product heads, and the quantities consumed. From this, I can determine the unit values, i.e the average price of all goods purchased under that product category. This is standard for a household consumption survey, because collecting data on the exact prices of every good purchased by each respondent would be a voluminous undertaking.

I use the UN Comtrade database, to get aggregate figures on final manufactured goods trade, and the imports of capital goods into India. I also use data from the World Inequality Database for the income distribution in India.

1.2.2 Patterns in Informality

Patterns in Prices and Consumption

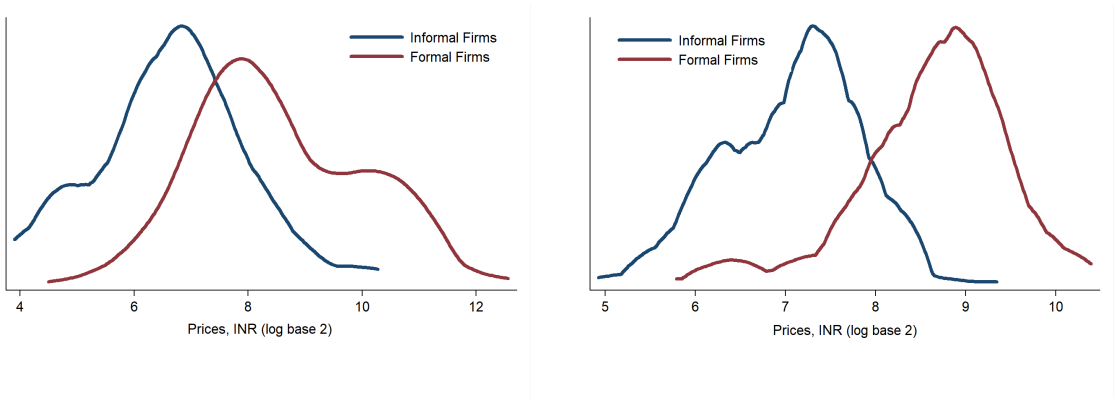
In this subsection I look to establish the following

- Informal firms make lower quality variants of the same good as compared to formal firms
- Consumers with higher income/monthly per-capita expenditure seek higher quality, and in so doing move away from purchasing informally made variants (i.e. the informal expenditure share declines with income)
- Consumers seeking varieties of a quality beyond a certain level will find their choice limited to formally made variants, and as a result all their expenditure on that product category will be directed towards formal varieties.

Before dissecting the microdata from India, a noteworthy sign that formal and informal firms make different variants of goods that they sell to different consumers comes from the World Bank's Enterprise Survey. This survey reports that while about half of all formal firms in India report facing some degree of competition from informal firms, only 17% consider the practices of informal firms to be a major impediment. The median formal firm considers informal firms to be a minor obstacle. Even within the half who report facing competition, there are caveats. While on average, formal firms have 13 times the revenue productivity of informal firms, there is some overlap in the productivity distributions of formal and informal firms (Nataraj (2011)). The

least productive formal firms are closer in characteristics to their informal counterparts, than to large formal firms. The extent to which formal firms report competition from informal firms as a significant factor drops further as we narrow down to the larger formal firms (Allen and Schipper (2016), Lamanna and Gonzales (2007)).

As is conventional, price is the most direct observed variable that indicates quality, and so I will proxy it for the latter. Although other factors may be at play (differences in bargaining power, differences in the opportunity cost of search etc), quality is generally seen to be the predominant differentiator (Deaton (1988)) that results in different prices. Values of prices of goods sold are gathered from the 2005-06 Unorganised Manufacturing Survey for informal firms and the corresponding year's ASI for formal firms. It should be noted that the data that we gather from these sources is not without noise and error, because it is recovered from aggregate sales and quantities sold for each product, and the quantities are sometimes recorded in incorrect units. Correcting these to the extent possible, I plot the kernel smoothed density plots of the prices of the same good sold by formal and informal firms producing figures such as Figure 1.2.



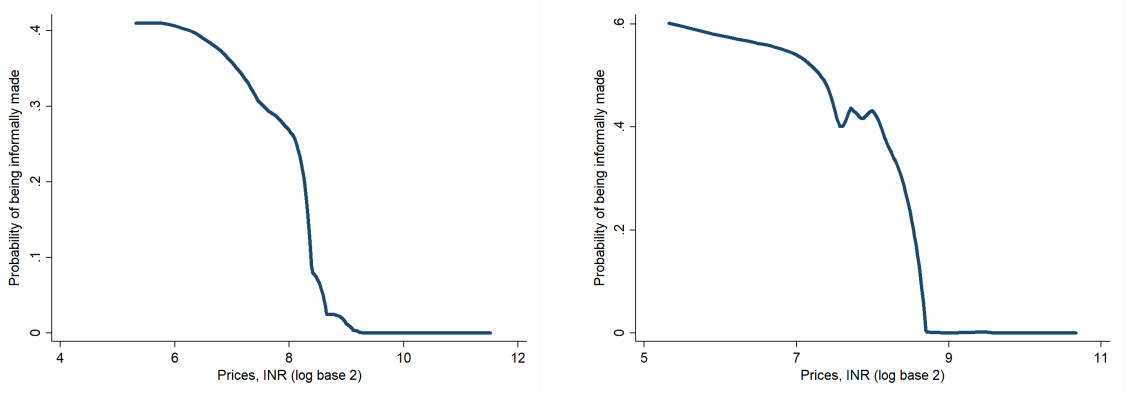
(a) Distribution of Prices of Ready-Made Clothing Articles Manufactured

(b) Distribution of Prices of Leather Footwear Articles Manufactured

Figure 1.2: Kernel smoothed distributions of prices of select articles manufactured (in INR) by formal and informal firms

The distribution of prices of a product produced by formal firms, lies substantially to the right of the distribution of prices of the same product produced by informal firms, indicating that formal firms make higher quality varieties of the same good.

There is considerable heterogeneity in prices within the formal or informal varieties of either good; however my emphasis here will be on delineating formal firms from informal firms rather than exploring the heterogeneity within those categories. To an extent, this dispersion is exacerbated by the fact that the product categories are broad. Although the enterprise data allows us to drill down to a narrow 5 digit product code, the limitation is the household consumption data that I will next compare this to. The household consumption survey, only uses broad product categories, and that is what I use to examine how consumers at different income levels choose the quality of the product they buy.



(a) Probability of Ready-Made Clothing Articles being informally made

(b) Probability of Leather Footwear Articles being informally made

Figure 1.3: Probability of select products being informally made vs price (in INR, log base 2)

Throughout this subsection, I will use at ready made clothing and leather footwear [8] as my two representative categories of goods. This is because they are clearly delineated in the household consumption survey, and they are product categories where both formal and informal firms have a sizable presence. I re-weight the data used in Figure 1.2 using the quantities produced by firms, to produce graphs of the probability of a product being informally made given its price. That is plotted in Figure 1.3. Articles beyond certain level of price (implied quality) are made only by formal firms.

Turning toward consumer data, the NSSO's Household Consumer Survey from

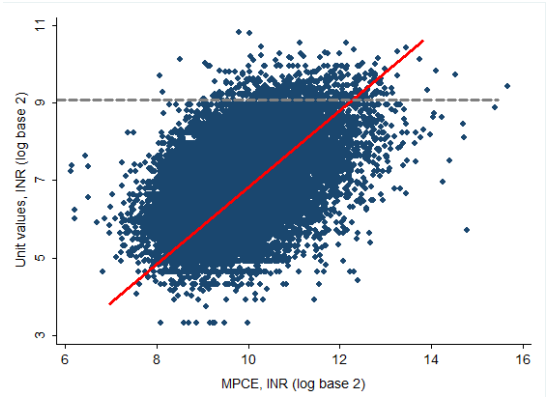
[8]Differentiated from other clothing which is stitched to measure by a tailor, a popular and economical means of procuring clothing in India where labor is inexpensive

the same year gives us the unit values (average prices) that each household pays for a category of goods. Unit values are computed from the aggregate expenditure towards that product category divided by the quantity of goods purchased under that category. Also provided, is the monthly per-capital expenditure (MPCE) for households, which can be proxied for income. Figure 1.4 plots the unit values of ready made clothing and leather footwear purchased vs monthly per capita expenditures (MPCE) of those households. It conveys a clear trend of households with greater MPCE choosing to purchase more expensive variants of the same products, and the red line represents the regression line $lnu_i = \alpha + \beta lnMPCE_i + e_i$, where u_i is unit value. This is known in the literature as quality upgrading (Deaton (1988)). The dashed grey lines indicate the price above which the good has a less than 0.1% probability of being formally made. A minority of varieties consumed fall into this region, but these are the most expensive varieties, and account for a disproportionate share of the total value of these goods consumed.

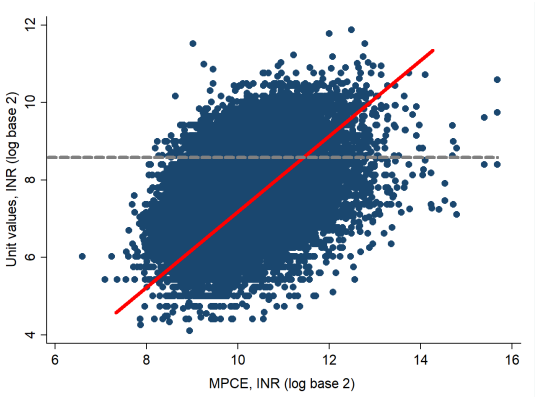
Figure 1.4 could be influenced by heterogeneity in the geographic distribution of prices. Regions with higher per-capita income might also be facing higher prices for goods of the same quality, causing a positive correlation between MPCE and unit values of goods purchased which has nothing to do with quality. In order to alleviate this concern, we can repeat part of the process used in Deaton (1988) to take spatial variation in prices seriously. The following modified equation is considered, wherein c denotes a district and prices are allowed to vary by district.

$$lnu_{ic} = \alpha_c + \beta lnMPCE_{ic} + \gamma z_{ic} + \theta lnp_c + e_{ic}$$

An additional vector of household characteristics (the age and gender distribution of the family's members) z_{ic} is also supplied as an independent variable. Running a fixed effects regression, β and γ can be obtained even without specifying p_c because this is lost when equation is demeaned from the district average. The parameter of interest is β, because this is the elasticity of unit value with respect to MPCE, is the quality elasticity. The values of $\hat{\beta}$ for ready-made articles of clothing and leather footwear are 0.45 (0.00008) and 0.63 (0.00005) respectively. These are significantly different from zero implying a strong tendency to consume higher unit value goods with rising income.



(a) Scatter plot of Unit Values of Ready-Made Clothing Articles purchased vs MPCE



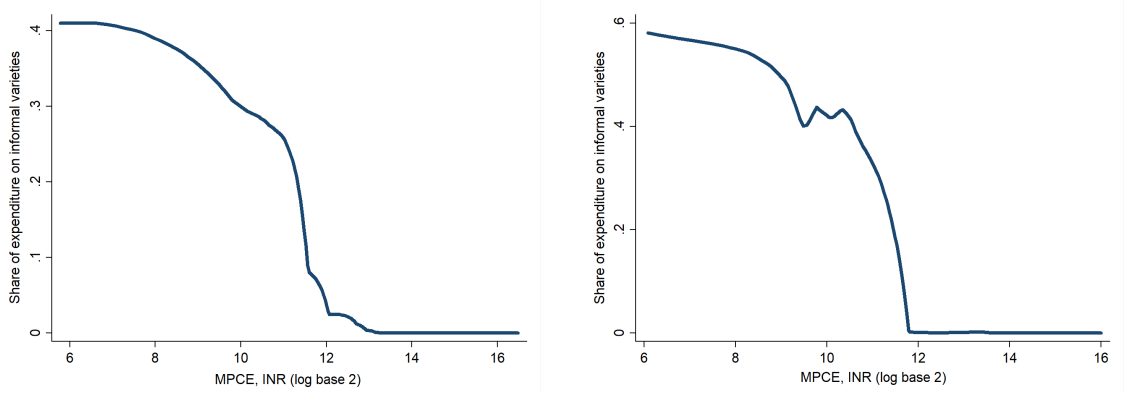
(b) Scatter plot of Unit Values of Leather Footwear Articles purchased vs MPCE

Figure 1.4: Scatter plots of Unit Values (in INR, log base 2) of goods consumed vs monthly per capita expenditure of the household consuming them. Dashed grey line indicates the price above which a variety of this good is almost certainly formally made.

The relationship between unit value and MPCE which Figure 1.4 implies, can be used to recast the x-axis in Figure 1.3. Knowing the $MPCE$ at which a household buys each good whose average price is u, I can plot this against the informal expenditure share that this price implies (this would be the same as the probability of the purchase being informally made), resulting in an expenditure share Engel for each product.

Ideally it would be best to have direct data on informal and formal expenditure shares, instead of following the circuitous route of assessing it via the price of the good consumed. However, such data is not generally available, and other works on this subject also use proxies in its place. Bachas et al. (2019) for example, assigns goods a tag of formal or informal based on the kind of store it is purchased in. Note here, that I do not come up with overall informal expenditure shares, but rather expenditure shares for specific product categories. Some manufactured products, such as high end electronics, or cars for example, are not produced by informal firms at all. Agricultural products, such as non-processed fresh farm products in India, are hardly ever formally produced. For such goods, there will not be such a decisive transition, or possibly any transition at all from consuming informal varieties to formal ones. The shape of the Engel curve seen in Figure 1.5 can be seen to represent only those manufactured goods which both formal and informal firms produce. That

being said, these are two significant product categories in consumer expenditure, and the data indicates that high income consumers move out of consuming informally manufactured variants of these products, and income gains that accrue to people in this segment can result in no further reduction in demand for these variants. In other words, income elasticity of informal expenditure share is very low among high income consumers.



(a) Informal expenditure share when purchasing ready-made clothing articles vs MPCE

(b) Informal expenditure share when purchasing leather footwear articles vs MPCE

Figure 1.5: Expenditure share Engel curves for select products

Patterns in Input Usage

This subsection looks to show that

- Formal manufacturing firms use capital and skilled labor as inputs, while informal firms use mostly unskilled labor.
- Over the decade 2000-2010, there is a sharp rise in formal firm capital intensity accompanied by an intensification of skill selectivity

Formal manufacturing firms are far more capital intensive than their informal counterparts. In order to show this in the Indian context, I regress capital intensity using a combined data-set of formal and informal manufacturing firms on a formality dummy and firm size. Firm size is included as an regressor because informal firms are smaller, and in general small firms are less capital intensive. It's important to assess whether formality has an effect which is separate from this.

Table 1.2: Capital Intensity Regressions: Total Capital Intensity in Formal and Informal Firms

Dep Var: Log Tot Capital Intensity				
	(1)	(2)	(3)	(4)
Formal	2.8092***	2.8276***		
Log Size (no of employees)	0.0001***		0.0002***	-0.0064
cons	4.3433***	4.3436***	6.9908***	4.3544***
Sample	All	All	Formal Only	Informal Only
N	136,053	136,053	36,392	99,661
R^2	0.1294	0.1294	0.1255	0.1177

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

Data from ASI 2010-11, and NSSO Unincorporated Non-Agricultural Enterprises Survey 2010-11. Capital intensity is measured as fixed assets in 000' INR divided by the number of employees. All regressions include state-urban/rural fixed effects as well as product category fixed effects.

This being a semi-log regression, the coefficient on the formal dummy in (2) implies that the ratio of total capital intensity [9] between formal and informal firms is $e^{2.8276} = 16.9$, which is remarkably high. Firm size is less vital than the status of being formal or informal. Adding a new employee only changes capital intensity by 0.02% among formal firms, and is not significant among informal firms. This is often traced to the financial constraints that informal firms face. La Porta and Shleifer (2014) find based on World Bank Enterprises Surveys that around 44 percent of informal enterprises list access to financing as the main obstacle of doing business, whereas this number is 21 and 14 percent for small and large formal enterprises, respectively.

The value of capital intensity used in Table 1.2 is computed as all fixed assets (encompassing land, buildings, transportation equipment and so on in addition to the plant machinery) used in production, divided by the total number of employees engaged. It can be argued that plant machinery is the component of the fixed assets that actually constitutes a variable input into production (the others being more in the line of fixed startup costs). Repeating the exercise with just the investment in plant machinery per employee (Appendix A), formal manufacturing firms pair their employees with 60 times more plant machinery than informal firms. This is because while plant machinery constitutes 68.2% of the value of fixed assets employed by

[9] To be precise, it is the ratio of their geometric means

formal firms, it only constitutes 3.5% of the value of fixed assets employed by informal firms. The fixed assets of informal firms are overwhelmingly accounted for by land value, and to a lesser extent building value. By and large, informal firms use a manual mode of production.

Over the decade in question (1999-00 to 2010-11), formal manufacturing firms have nearly doubled their average capital intensity (Figure 1.6). The average size of a formal firm in terms of the number of employees has remained steady, contrary to the expectation that average firm size increases with per-capita GDP (Hopenhayn (2016)). However, capital use per formal firm has grown by nearly 90%. While productivity gains also exist, the increased output per firm is clearly driven in part by the heightened use of capital.

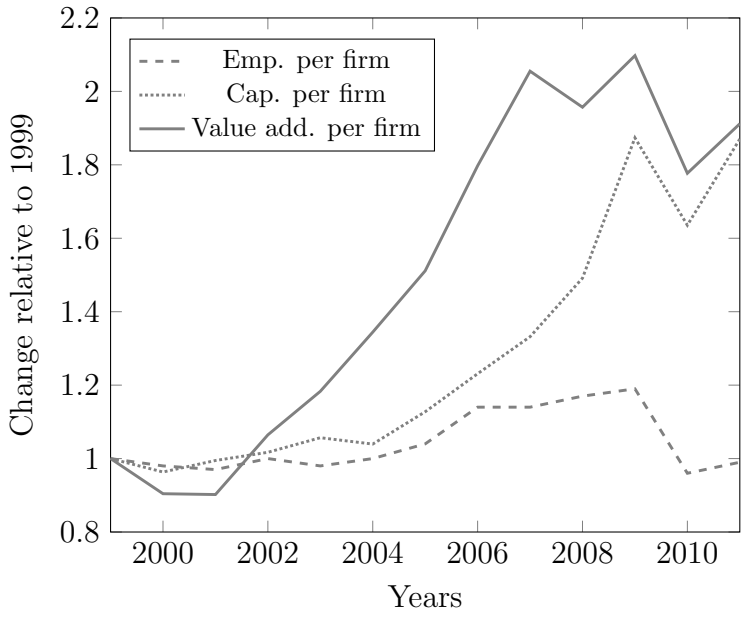


Figure 1.6: Capital use in formal manufacturing firms over 1999-2011, with capital deflated by the wholesale price index for machinery and machine tools

Source: Author's calculations from ASI summary data

Das et al. (2009) notes that the phenomenon of increasing capital intensity in the formal firms is not restricted to product categories that could be considered capital intensive, but also afflicts those traditionally considered labor intensive. The labor regulatory framework has not made labor more expensive over this period. On a state

by state basis, it has either remained the same, or become more permissive (Dougherty (2009)). The shift in favor of capital is shown to be driven more by the falling cost of capital relative to labor (Sen and Das (2014)). An important component of this, is the reduced cost of imported capital goods following trade liberalisation (Kandilov and Leblebicio (2019)).

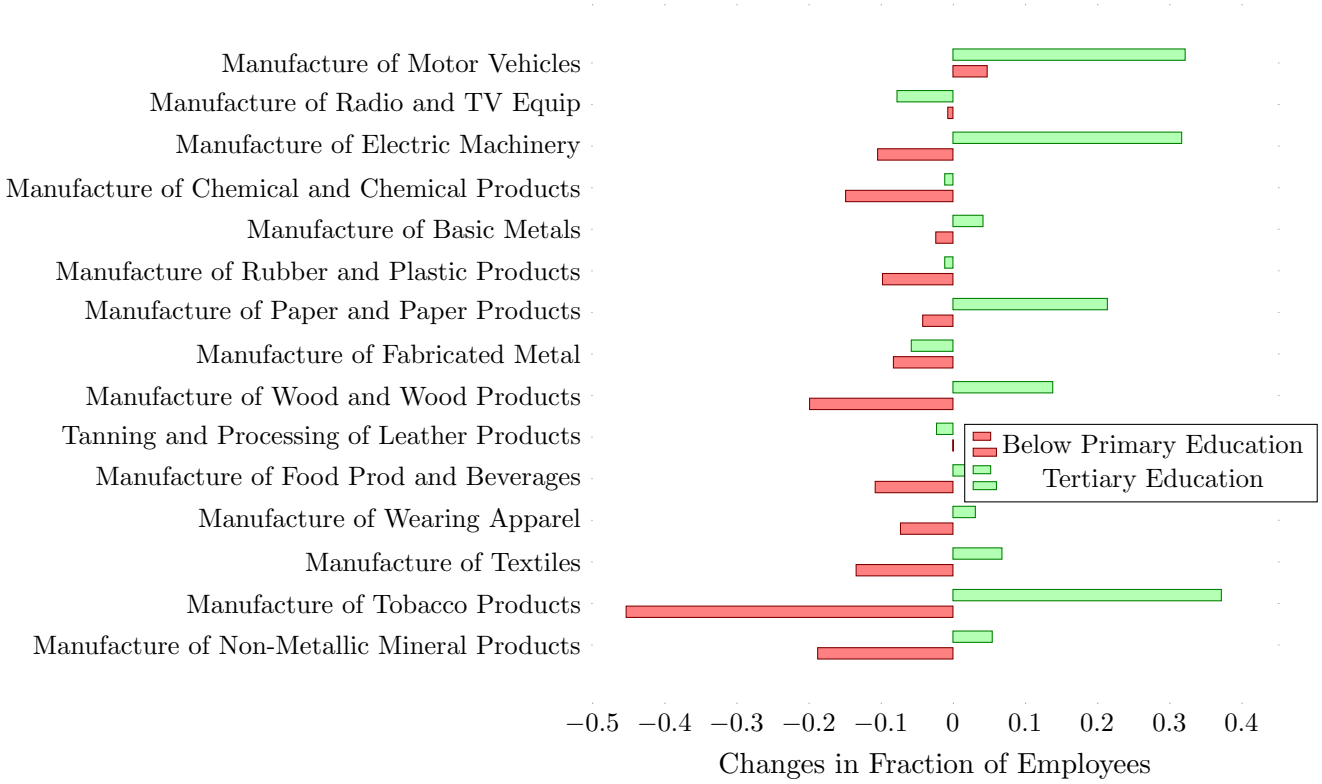


Figure 1.7: Changes in the Fraction of Employees with Tertiary Education, and Below Primary Education in Formal Firms between 1999-00 and 2009-10

Source: 55th and 66th rounds of the NSS Employment and Unemployment Survey

While the average number of employees per formal firm was relatively stable, its composition was changing. The NSSO's employment and unemployment survey allows us to examine the educational background of workers in various product segments of the economy who work in manufacturing firms that can be identified as formal. Across most product categories, formal manufacturing firms were reducing the fraction of their workforce that has a below primary education, and increasing the fraction with tertiary education (Figure 1.7). Taking educational attainment as analogous to skill,

I refer to this as increased skill selectivity. The probability of being hired by formal firms is increases with skill/educational attainment. In other words, formal firms are "selective" in seeking high skill workers. Doing this comparison by product category is important because an overall increase in skill selectivity can be caused by compositional effects, with a skill indifferent product segment declining and a skill intensive one growing in the economy. What is seen though, is that manufacturing formal firms in each product segment, already skill intensive, were becoming more so. This was despite a rising skill premium in India (Azam (2010)), which was making employees with higher educational attainments more expensive to hire.

Table 1.3: Education composition of the manufacturing workforce, and probability of formal employment 1999-00 to 2010-11

	%age of Manuf. Labor		%age Formally Employed	
	1999-00	2010-11	1999-00	2010-11
Below Primary Education	44.54%	32.82%	12.74%	10.37%
Primary and Middle School	32.14%	36.66%	22.12%	20.03%
Secondary and Higher Sec.	17.32%	22.48%	39.47%	36.05%
Tertiary Education	5.99%	8.04%	56.45%	59.66%

As noted in the introduction, between 2000 and 2010, there was a large change in the overall education composition of the population. Of the total population over the age of 15, the fraction with less than a primary education reduced by 11%, in favor of higher attainments, chiefly secondary educational attainment (Barro-Lee data). The educational composition of the workforce involved in manufacturing also moved in tandem (Table 1.3). If the probability of being selected into formal employment conditional on skill was unchanged, this should have mechanically led to higher formal manufacturing employment. It did not, because those formal firms intensified their skill selectivity i.e, they further reduced the probability of a low skill worker being hired.

1.2.3 Institutional Features of India

Informal firms are defined as unregistered firms, consistent with the definition of informality applied in other developing countries. The institutional setup in India is unique however, in that firms with fewer than 10 employees (or twenty people if they use no power consuming machinery) are legally permitted to be unregistered. Therefore, unlike most other developing countries, informality is not inherently illegal. In the manufacturing sector in 2010-11, informal number about 17 million and employ some 35 million people. The average informal firm in India therefore employs around 2 people, and a third are one person firms. The vast majority lie well under the 10 person threshold, allowing them to operate informally without contravening the law (Hasan and Jandoc (2010)).

A positive aspect of this from the point of view of research is that this results in good data on informal firms since they do not exist in fear of the government, and are more responsive to surveyors. This also implies that as a factor in reducing informality with growth, the institutional capacity to identify and penalize informal firms is not as relevant in the Indian context. In addition to not requiring them to register, India also does not require firms below a size threshold to follow most regulations, pay benefits to their employees or pay corporate taxes.

In its appendix, Amirapu and Gechter (2017) gives a thorough listing of the size based regulations in India, and most of the country's pivotal enterprise regulation legislations feature in this list. The Factories Act 1948, which apart from setting the registration requirement, also regulates conditions of service for workers, kicks in above ten employees. The Industrial Disputes Act 1947, which regulates the settlement of disputes and the termination of permanent employees, applies largely to firms over a 100 employees (with differences across states). Various acts regulating benefits and pay, such as the Payment of Gratuity Act 1972 (requiring payment of gratuities upon retirement or resignation), the Payment of Bonus Act 1965 (requiring the payment of bonuses if the firm is profitable), and the Payment of Wages Act 1936, all apply only to firms with more than 10 employees. The Employees Provident Fund and Miscellaneous Provisions Act 1952, requires the establishment of a contributory provident fund for every permanent employee set at 24% of the wage, split equally between employer and employee, and applies to firms with over 20 employees.

Informal firms also do not pay a corporate tax on their profits. The owner is expected to account for those profits as personal income, and pay the requisite rate of income tax on them. However, the threshold at which income taxes kick in excludes most informal firm owners. The average GVA per enterprise for informal manufacturing firms (which would be upper bound on profits for owner) was INR 89,900 in 2010-11, while the lower threshold for the applicability of income tax even absent any deductions was INR 160,000 [10]. Under-reporting and evasion are also commonplace. All firms however, are required to pay taxes on their sales of goods. In 2005, midway through the period we use (1999-00 to 2010-11), India switched from a system of retail sales taxes to a system of value added taxes (VAT). The change was an effort to avoid double taxation as well as incentivize informal firms to voluntarily comply. The notion being that large downstream players who were too big to avoid being taxed, would in turn look to be supplied only by other VAT paying firms because they wouldn't be able to claim an input tax rebate otherwise. Research shows (Briand and Hoseini (2015)) that the change increased tax registration by less than 1% overall, and increases in registration and compliance were restricted to those firms with significant downstream linkages (Rios and Seetharam (2017)). In the period we focus on, the Indian government also charged an excise tax on production (later replaced by an integrated Goods and Service Tax in 2017). This was levied at the factory gate rather, and small firms (below a turnover of 10 million rupees) were eligible for a 100% exemption on paying them. On the whole, for modelling purposes, I will take informal firms as paying neither a sales/excise tax nor a corporate tax.

It's important to note here that there is an aspect of informality that I do not model in this paper. This is the use of contract labour by formal firms, i.e. the intensive margin of informality. I make the simplifying assumption that all employees of formal firms are formally employed, which is to say they receive the intended benefits and protections of formal employment. Other papers such as Bertrand et al. (2015) explore this aspect of informal employment.

[10] Deductions available to most households and household businesses would double this figure

1.3 Model

The model that follows combines three major pieces. In its outer architecture, it is a firm based open economy model that follows Melitz (2003) in modelling heterogeneous firms, an environment of monopolistic competition, and a fixed cost of exporting. This is a standard choice in line with the firm based trade literature. The demand function, instead of the traditional CES form, is non-homothetic with the income elasticity of informal expenditure share dropping off at high income levels. This is in line with the consumer data that has been shown in the previous section.

The production side of the model has multiple goals to fulfill. It has to sustain a range of incomes for the preferences to result in a range of different consumption baskets. It has to tie in with the data which shows that formal firms are skill intensive relative to their informal counterparts, and that the composition of labor in formal firms shifted further towards skilled labor with rising capital intensity. It has to allow for this shift to take place even with rising skill premia. This is accomplished by using a task based production framework of the kind seen in Costinot and Vogel (2010) where labor of heterogeneous skill or capital can be used to complete tasks leading to the production of a unit of output. I begin by describing consumer preferences.

1.3.1 Preferences

Consumer preferences have a two tier structure. There is a continuum of firms producing unique goods indexed by i (both the firm and the good they produce have the same index since there is a one to one mapping). Firms will choose whether to operate formally or informally, and the goods produced by all firms choosing to operate formally are aggregated in a CES manner into the composite good Q^F. Similarly, the goods produced by all firms choosing to operate informally are aggregated into the composite good Q^I [11].

$$U = \begin{cases} \left[\left(Q^F + Q^I - \bar{C}\right)^{\rho_u} + \left(\delta Q^F\right)^{\rho_u}\right]^{\frac{1}{\rho_u}} \quad if \quad C > 0 \\ \\ Q^F + Q^I - \bar{C} \quad if \quad C \leq 0 \end{cases} \tag{1.1}$$

[11] I will use superscripts to denote formal and informal throughout the model, and subscripts for everything else

where

$$C = Q^F + Q^I - \bar{C}$$

and

$$Q^j = \left(\int_{\Omega^j} \alpha^{\frac{1}{\sigma^j}} q(\alpha)^{\frac{\sigma^j - 1}{\sigma^j}} M^j \mu^j(\alpha) d\alpha \right)^{\frac{\sigma^j}{\sigma^j - 1}} \tag{1.2}$$

$$\alpha \sim G(\alpha, \theta) \qquad \mu^j(\alpha) = \frac{g(\alpha | \alpha \in \Omega^j)}{\int_{\Omega^j} g(\alpha) d\alpha}$$

The top tier of the utility function is related to the generalized CES form in that one of its terms has an offset $\bar{C}$. Pollak (1971) features additive utility functions with an offset, and more recent works such as Jung, Simonovska and Weinberger(2019) feature the generalized CES form in particular. The difference here is that offset applies only to one term, and this the sum of Q^F and Q^I. This structure implies that as long as the consumption of Q^F exceeds $\bar{C}$, the consumption of Q^I can be driven all the way to zero because its marginal utility is not infinite at that level or any other. This particular function is presented in Armendariz (2015) in order to generate the indifference curves seen in Jensen and Miller (2008).

The utility function in Equation 1.1 is rationalised as follows. $\bar{C}$ is a subsistence threshold of consumption, and up till this is reached, the consumer will only consumer the cheaper option. Parameter specifications will ensure that Q^I is cheaper, and therefore at a low enough income level a consumer will spend all their income on informally produced goods. Formal goods however, do more than satisfying basic consumption needs. Their superior quality lends itself to provide an additional δ amount of satisfaction for every unit of Q^F consumed. $\frac{1}{1-\rho_u}$ is the elasticity of substitution between this additional satisfaction provided by purchasing formal goods, and the surplus consumed over and above the subsistence threshold.

In addition to the informal composite good costing less than its formal counterpart ($P^F > P^I$), two more assumptions are made on the parameters in Equation (1.1). The first is that $\rho_u < 0$, so that the additional satisfaction gained by consuming formal goods, and the surplus over the subsistence threshold are gross complements. This ensures that with rising income, a consumer will devote more of his/her income to

consuming formal goods. The second is that $\delta^{\rho_u} < \frac{P^F - P^I}{P^I}$. This condition is in place so as to prevent demand for Q^I from abruptly collapsing to zero once the threshold $\bar{C}$ is crossed. To match the data on the decline of informal expenditure share with income, the model should require that a consumer to reduces his/her consumption of the informal composite good in a controlled manner after the level of income where basic needs are met. In order for this to happen, this condition states that the higher the δ, the cheaper the informal composite good needs to be relative to the formal one to still justify its consumption. With these two conditions in place, the following well behaved demand functions conditional on wage/income (w) arise .

$$Q^F(w) = \begin{cases} 0 \quad if \quad w \leq P^I\bar{C} \\ \frac{\Lambda(P^I,P^F)(w-P^I\bar{C})}{P^I(\delta-\Lambda(P^I,P^F))+\Lambda(P^I,P^F)P^F} \quad if \quad P^I\bar{C} \leq w < \frac{\Lambda(P^I,P^F)P^F\bar{C}}{\Lambda(P^I,P^F)-\delta} \\ \frac{w}{P^F} \quad if \quad w \geq \frac{\Lambda(P^I,P^F)P^F\bar{C}}{\Lambda(P^I,P^F)-\delta} \end{cases} \tag{1.3}$$

and

$$Q^I(w) = \begin{cases} \frac{w}{P^I} \quad if \quad w \leq P^I\bar{C} \\ \frac{w(\delta-\Lambda(P^I,P^F))+\Lambda(P^I,P^F)P^F\bar{C}}{P^I(\delta-\Lambda(P^I,P^F))+\Lambda(P^I,P^F)P^F} \quad if \quad P^I\bar{C} \leq w < \frac{\Delta(P^I,P^F)P^F\bar{C}}{\Lambda(P^I,P^F)-\delta} \\ 0 \quad if \quad w \geq \frac{\Lambda(P^I,P^F)P^F\bar{C}}{\Lambda(P^I,P^F)-\delta} \end{cases} \tag{1.4}$$

where

$$\Lambda(P^I, P^F) = \left(\frac{P^F - P^I}{\delta P^I}\right)^{\frac{1}{\rho_u - 1}}$$

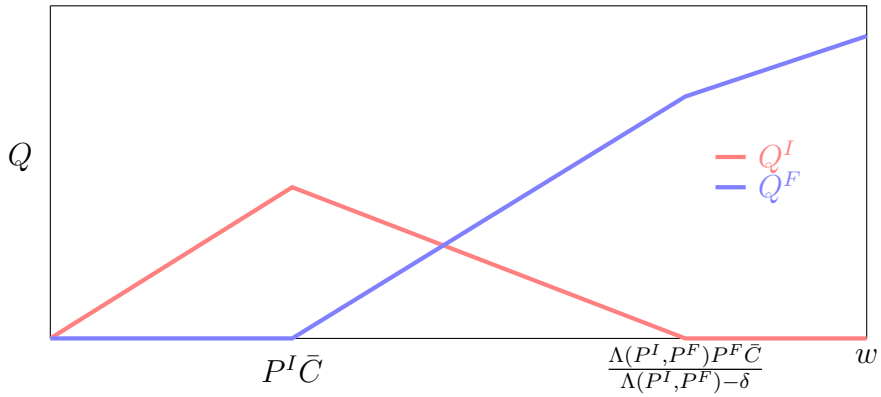


Figure 1.8: Engel curves showing the consumption of formal and informal composite goods plotted against income

The Engel curves shown in Figure 1.8 illustrate more clearly what is described in these equations. Q^I is clearly inferior over part of the income range, as consumers look beyond fulfilling basic needs to buying more modern manufactured goods produced by formal firms. Also, beyond the income level given by $\frac{\Lambda(P^I,P^F)P^F\bar{C}}{\Lambda(P^I,P^F)-\delta}$, all expenditure is on formal goods, and the informal expenditure share elasticity hits zero.

Equation (1.2) which describes the CES aggregation leading to Q^F and Q^I. α is a firm specific demand draw, from the distribution $G(\alpha)$. $\mu^j(\alpha)$ is the distribution of demand draws conditional on firms have chosen to be in sector $j \in \{I, F\}$. M^j is the mass of such firms. I prefer to define firm heterogeneity along this dimension instead of productivity. This is because if more productive firms sort into the formal sector, and charge lower prices for their goods, it would make the requirement that $P^I < P^F$ more challenging to maintain. This variant of the Melitz model with demand instead of productivity shifters is seen in papers such as Caliendo and Rossi-Hansberg (2012). σ^j, as usual, is the elasticity of substitution within goods of the same sector (formal or informal). Given the monopolistic competition structure, I adopt $\sigma^I > \sigma^F$ consistent with the evidence that formal firms are more profitable than their informal counterparts (Medvedev and Oviedo (2016)).

1.3.2 Production

As already previewed, there are two types of goods and two types of inputs that can be used to make them. The type of good, whether formal or informal is indexed by

$j \in \{I, F\}$, and will be superscripted. It is assumed that a firm which chooses to be informal/formal in equilibrium will produce the informal/formal good respectively. The type of input, whether labor or capital is indexed by $x \in \{w, k\}$, and will generally be subscripted. The idea of task based production (Acemoglu and Autor (2011), Autor et al. (2003), Costinot and Vogel (2010), Garicano (2000), Garricano and Rossi-Hansberg (2006)), is that a series of tasks need to be completed for a good to be produced.

In this model, to produce a good of type j, a continuum of tasks given by $z \in [0, z^j]$ has to be done b^j number of times each. Here z indexes both the task as well its complexity/difficulty, and a task with a higher z is considered more demanding to complete. In concrete terms, this implies that any given input cannot have a higher productivity at performing a task of higher z than a lower one. With that interpretation in mind, I choose $z^I < z^F$, which means that to make a formal good (assumed to be of higher quality) requires completing an additional measure of tasks over and above an informal one.

Workers and Capital

Having introduced the tasks to be performed, this subsection speaks to the productivity of the two inputs at completing them. Workers are heterogeneous in skill, and can have any level of skill s, distributed $H(s)$ with support between s_{low} and s_{hi}. Having a continuum of skill instead of discrete levels, will lend itself going forward to creating a continuum of possible incomes. The productivity of a workers of skill s at completing task z is given by Equation (1.5), and follow the form seen in Feng and Graetz (2015), which in itself is an extension of Costinot and Vogel (2010).

$$\psi_w(s,z) = \begin{cases} A_w \left[1 - min\left(\frac{z-\bar{z}_w}{s}, 1\right)\right] & if \quad z > \bar{z}_w \\ \\ A_w \quad if \quad z \leq \bar{z}_w \end{cases} \tag{1.5}$$

This functional form can be rationalised as follows. Some tasks $z \in [0, \bar{z}_w]$ are simple enough that a worker of any skill is able to do with equal productivity A_w. These are so called "innate ability" tasks in line with the terminology used in Feng and Graetz (2015). For more complex tasks, a worker has to learn how to do them, and skill

signifies the ease with which a worker is able to do so. To learn how to complete a task $z \geq \bar{z}_w$, a worker with skill s spends $\frac{z-\bar{z}_w}{s}$ fraction of his time training, capped at 1. He then has $1 - \frac{z-\bar{z}_w}{s}$ fraction of his time left over for actual production. Mathematically, all that is required is that productivity $\psi_w(s, z)$ is log supermodular in s and z beyond $z > \bar{z}_w$. This condition ensures a monotonic assignment of workers to tasks based on comparative advantage.

Having already assumed that $z^I < z^F$, I will additionally assume $z^I \leq \bar{z}_w < z^F$. This simplifies things substantially by making informal firms entirely skill indifferent, because producing the informal good involves only "innate ability" tasks. Formal firms will end up being skill-selective because making the higher quality formal good involves complex tasks where skill is relevant.

Capital/machines constitute the other input that firms can use. Machines are not heterogeneous, however, they too face reduced productivity when assigned to tasks more complexity than $\bar{z}_k$. Given $\upsilon < 1$, the marginal cost of using capital at tasks $z \geq \bar{z}_k$ will rise in a convex manner. The productivity of a unit measure of capital when assigned to a task z is given by Equation (1.6)

$$\psi_k(z) = \begin{cases} \frac{A_k}{\left[1+(z-\bar{z}_k)^{\frac{1}{\upsilon}}\right]} & if \quad z > \bar{z}_k \\ \\ A_k & if \quad z \leq \bar{z}_k \end{cases} \tag{1.6}$$

Choice of Inputs

As noted earlier, having a continuum of skills will support a continuum of incomes. Skill will also determine who sorts into formal and informal firms. Therefore, I can index the equilibrium wage schedule solely by skill as $w(s)$ (and this will be non-decreasing in skill). The cost of using capital will be exogenously specified to be greater for informal firms than formal firms $c_k^I > c_k^F$ owing to informal sector firms having restricted access to the banking system (La Porta and Shleifer (2014)). This is a relatively standard means of matching the data showing that informal firms use far less capital than their formal counterparts. For both formal and informal firms, the choice of which input to use for which task comes down to the marginal cost of doing so.

The marginal cost of assigning workers of skill s to complete one unit of a task of complexity z is given by $mc_w^F(s,z)$ and $mc_w^I(s,z)$ for formal and informal firms.

$$mc_w^F(s,z) = \frac{w(s)(1+t_w)}{\psi_w(s,z)}$$
$$mc_w^I(s,z) = \frac{w(s)}{\psi_w(s,z)}$$

Here t_w incorporates the additional costs that formal firms face in hiring workers by virtue of the regulatory requirement they face to contribute to a provident fund, pay bonuses and gratuities. While assigning workers to tasks, there will be an optimal assignment of workers of a skill s to a task of complexity z. I elaborate on this assignment in the subsequent subsection, but for now, the reader should assume that such an assignment is possible. This implies that the marginal cost of using labor can be rewritten just in terms of the task z as $\widehat{mc}_w^F(z)$ and $\widehat{mc}_w^I(z)$ respectively. In parallel, the marginal costs of using capital to complete one unit of a task z are given by $\widehat{mc}_k^F(z) = \frac{c_k^F}{\psi_k(z)}$ and $\widehat{mc}_k^I(z) = \frac{c_k^I}{\psi_k(z)}$. Since formal and informal firms are performing different different ranges of tasks, and face different input costs, I look at their choice of task-wise inputs separately before returning to the economy as a whole.

Formal Firms

Producing a unit of a formal good involves completing tasks $z \in [0, z^F]$. This is the space over which inputs need to be assigned. Given certain conditions formalized in Lemma 1, the marginal costs of assigning capital or labor to these tasks will look something like Figure 1.9.

Lemma 1: Given $\frac{A_k}{A_w} > \frac{c_{kH}^F}{w(s_{low})(1+t_w)}$, $\bar{z}_k < z_F - 1$ and a low enough value of ν, there always exists a value $z^* \in (0, z^F)$ such that $\widehat{mc}_k^F(z) < \widehat{mc}_w^F(z)$ if $z \in [0, z^*)$, and $\widehat{mc}_k^F(z) \geq \widehat{mc}_w^F(z)$ if $z \in [z^*, z^F]$.

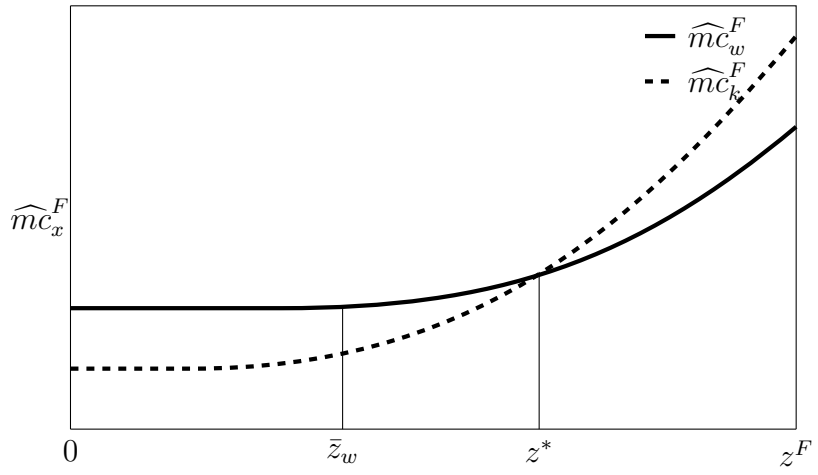


Figure 1.9: Task wise marginal cost of capital and labor for formal firms

As seen, there is a dividing task z^* which is an endogenously determined threshold that separates the tasks assigned to workers and machines by formal firms. In the task space $z \in [0, z^*)$, capital is employed because it can perform the task at a lower marginal cost, and in the task space $[z^*, z^F]$, labor is used. Ensuring that capital is advantaged at simpler tasks is a deliberate choice that tracks with the anecdotal evidence, and is standard in the task based production literature (Acemoglu and Autor (2019)). If one were to visualize a clothing firm for example. The simple task of achieving a rapid and even stitch is done by machines. In the parlance of the literature, this might also be referred to as a "routine task". The more complex task of directing that stitching to form wearable apparel is done by moderately skilled workers, and the most complex task of designing the clothing to match consumer demand is done by highly skilled workers.

Informal Firms

Informal firms produce a lower quality good and their product only involves performing tasks in a shorter range $z \in [0, z^I]$ where $z^I < \bar{z}_w$. Since all these tasks are innate ability tasks, with workers of any skill having an equal productivity at doing them, $\widehat{mc}_w^I(z)$ is going to be constant across z (further discussion follows in the next subsection).

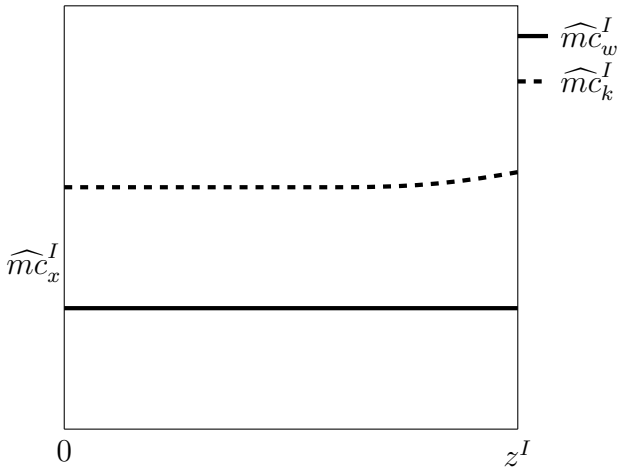


Figure 1.10: Task wise marginal cost of capital and labor for informal firms

Importantly, the design choice with regard to capital costs is that informal firms face a higher cost of capital $c_k^I = c_k^F + d$ compared to formal firms. Raising c_k^I sufficiently, ensures that the marginal cost of employing capital for any task is above the cost of using labor over the whole task spectrum $[0, z^I]$. This pushes informal firms to employ only labor for all the tasks involved in producing their product. While the reality is not quite that extreme, the data from India shows that informal firms use 60 times less plant and machinery per employee than formal firms (Data section).

Sorting, Wages and Assignment

Formal firms seek workers for tasks $[z^*, z^F]$, and as noted, the productivity of workers at tasks that are more complex than $\bar{z}_w$ depends on skill. Things can be made simpler by choosing parameters to ensure that $z^* > \bar{z}_w$ in equilibrium. This would mean that *all* the tasks which formal firms assign to workers in equilibrium are tasks that where the productivity of labor is conditional on skill. In contrast, *none* of the tasks $[0, z^I]$ that informal firms seek workers for are tasks that where the productivity of labor is conditional on skill. Given that informal firms are skill indifferent, and formal firms clearly value skill in the task space where they use labor, there is in equilibrium a threshold level of skill $s^* \in [s_{low}, s_{hi}]$ above which workers are selected into formal firms, and below which they end up working in informal firms. Formally, if $n_w(s, z)$ is defined as the measure of workers of skill s who are assigned to perform a task of

complexity z once, the following is true.

Lemma 2: In equilibrium, there will exist $s^* \in [s_{low}, s_{hi}]$ such that $n_w(s,z) > 0$ for $z \geq z^*$ if and only if $s \geq s^*$.

In other words, the assignment structure looks something like this

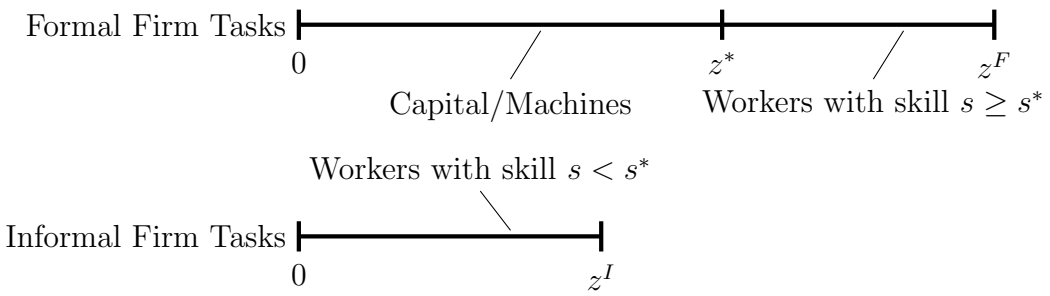


Figure 1.11: Assignment of inputs to tasks performed across formal and informal firms

Within the ambit of the labor employed by informal firms, the assignment of skill to tasks is degenerate. All workers of skill $s < s^*$ are employed in these firms have the same marginal product of labor, and they all earn an equal wage given by w^I. Therefore, there is a mass point in the overall wage distribution, and in the region $s \in [s^*, s_{hi}])$ $w(s)$ is given by Equation (1.7).

$$w(s) = w^I \quad \forall \quad s \in [0, s^*] \tag{1.7}$$

Things are less straightforward in formal firms, and the assignment of workers with skill $s \in [s^*, s_{hi}]$, to tasks in the range $[z^*, z^F]$ is non trivial. In this task range, the productivity of workers $\psi_w(s,z)$ as given in Equation (1.5) is log-supermodular in s and z. This implies that there is a comparative advantage in assigning a worker of higher skill to a task of higher complexity. In other words if $s" > s'$ and $z" > z'$, then $\frac{\psi_w(s",z")}{\psi_w(s',z")} > \frac{\psi_w(s",z')}{\psi_w(s',z')}$. This leads to Lemma 3

Lemma 3: In equilibrium, given $z^* > \bar{z}_w$, there exists a continuous and strictly increasing matching function $\phi : [s^*, s_{hi}] \to [z^*, z^F]$, such that $n_w(s,z) > 0$ if and only

if $\phi(s) = z$. In addition, $\phi(s^*) = z^*$ and $\phi(s_{hi}) = z^F$.

This is a direct extension of Lemma 2 in Costinot and Vogel (2010), with the change being that two of the boundaries, namely s^* and z^* are endogenous. However, this extension is itself proven in Feng and Graetz (2015) , who show it to be fairly straightforward. Given the existence of the matching function $\phi(s)$, the manner in which it is solved for also follows Costinot and Vogel (2010) with very minor variations, and is shown in Appendix C. As is standard in the task based production literature, there isn't a closed form solution for the matching and wage function. Rather, there are two coupled differential equations which define them and have to be solved for numerically. These are given by Equations (1.8) and (1.9).

$$\frac{d\phi(s)}{ds} = \frac{\bar{L}h(s)\psi_w(s,\phi(s))}{b^F N^F} \qquad \forall \quad s \in [s^*, s_{hi}] \tag{1.8}$$

$$\frac{dlogw(s)}{ds} = \frac{\partial log\psi_w(s,\phi(s))}{\partial s} \tag{1.9}$$

Here, N^F denoted the total quantity of formal goods produced by all formal firms in the country. This is not the same as the CES aggregate of all formal goods given by Q^F. N^F simply represents the addition of the quantities of goods produced by all formal firms in equilibrium. Equation (1.8) is derived from market clearing for labor belonging to each skill s, and Equation (1.9) comes from minimising the marginal cost of each assignment. There are also the two no-arbitrage conditions at the endogenously determined thresholds s^* and z^*

$$\begin{aligned} w(s^*) &= w_I \\ \frac{c_k^F}{\psi_k(z^*)} &= \frac{w(s^*)(1+t_w)}{\psi_w(s^*,z^*)} \end{aligned} \tag{1.10}$$

The first is condition states that threshold worker receives the same pay in a formal firms or informal firm. The second condition states that the cost of using capital for the threshold task in formal firms is the same as that of using labor.

Visualizing Capital-Labor Interaction

In the setup described here, the informal sector is effectively residual. It uses workers too unskilled to get into formal firms, and puts them to work in an all manual process aimed at making at simpler and lower quality goods. Interactions between capital and labor, affecting the skill-selectiveness of the formal sector, happen within formal firms.

As an example, I consider what would happen in the formal sector if a shock occurred that led to capital costs falling. Figure 1.12a) shows what this implies for the marginal cost curves $\widehat{mc}_k^F(z)$ and $\widehat{mc}_w^F(z)$. The former is pushed downwards, and as a result, the threshold task z^* which divides the formal task space between capital and labor moves right to $z^{*\prime}$. This directly pushes up capital intensity, as more capital and less labor is being used to make each unit of the formal good. The tasks remaining with labor are the more complex tasks. The assignment of skill to task $\phi(s)$ changes to reflect this, and workers of any given skill who remain in formal employ are now assigned to more complex tasks than they earlier were Figure 1.12b). In the parlance of the literature, this is referred to as *task upgrading* (Costinot and Vogel (2010)). Task upgrading causes the the wage $w(s)$ to rise more sharply with skill. The higher $\frac{dw(s)}{ds}$ is reflected in Figure 1.12c).

The final matter of interest is what happens to s^*. On the one hand, the task which a worker of this skill used to do has now been handed over to capital, i.e automated. Keeping a worker of this skill in formal employment, would mean assigning him/her to the new threshold task $z^{*\prime}$, which is harder and at which this worker is less productive. This effect would push s^* higher, increasing skill selectivity. On the other hand, a lower cost of capital in equilibrium can only result from more prolific supply, either from domestic sources or international ones. Greater use of capital leads to more formal good production. While labor is called upon to do fewer tasks per unit of formal good being produced, more of these goods are being produced without an increase in the supply of skilled labor. This stretches the available supply, and pushes s^* lower. The outcome on balance is not pre-determined, but dependent on each particular equilibrium.

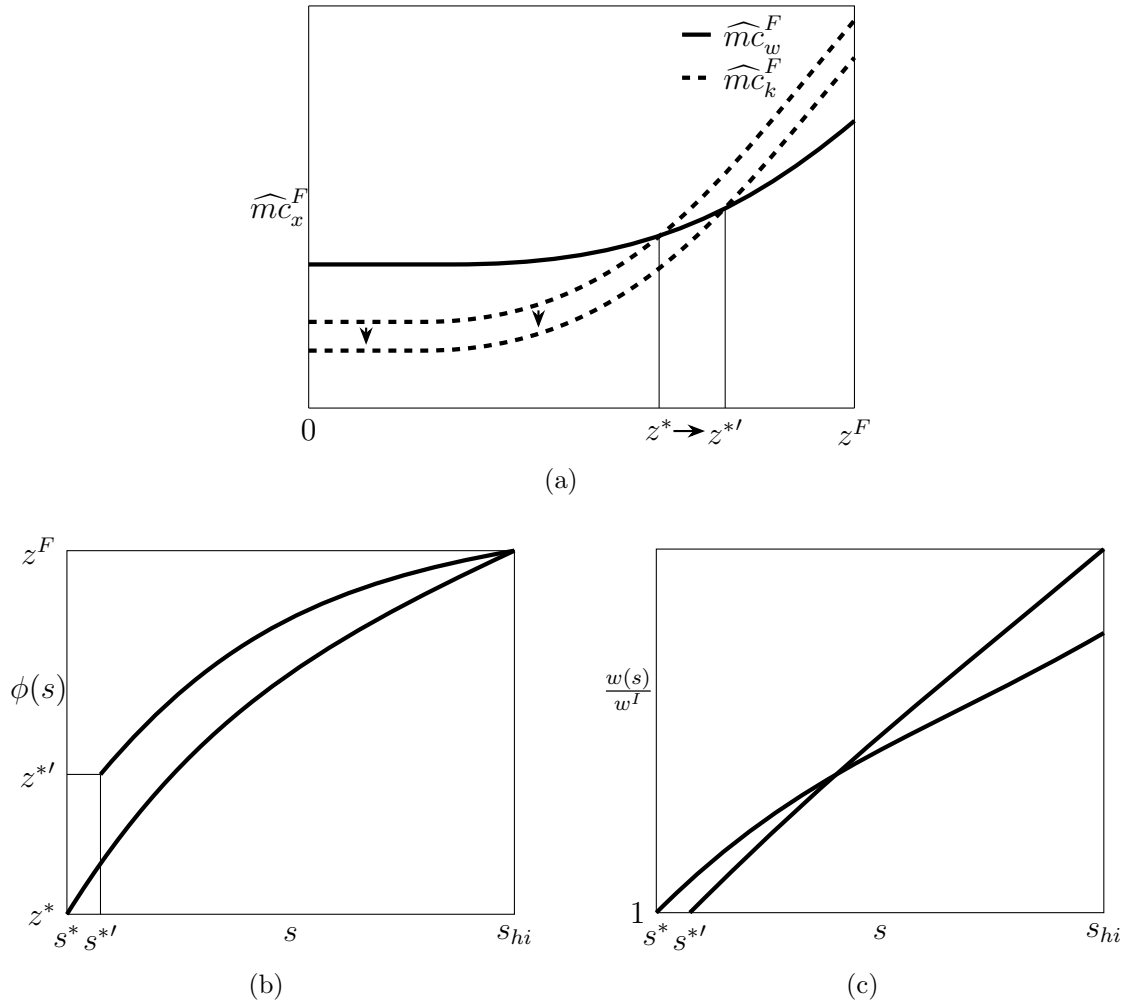


Figure 1.12: Changes in the formal marginal cost curves, matching function $\phi(s)$, and its companion wage function $w(s)$ in response to a lower price of capital

That being said, it certainly can be the case that $s^{*\prime} > s^*$. What that would mean is that a lower cost of capital would lead to higher capital intensity, higher skill premiums *and* higher skill selectivity in formal firms, tying in with the data from India. This is a difficult combination of outcomes to achieve in a canonical CES type production function. To combine lower usage of low skill labor despite higher skill premiums would require very high complementarity between capital and high skill labor, as well as a much steeper fall in capital costs. That same high complementarity would retard any increase in capital intensity, because capital would be stuck in fixed proportion to the most widely used kind of labor in formal firms (mathematical expressions are

given in Appendix E). Skill biased technological change, which would mean modifying the parameters of a canonical production function to reduce the weight of low skill labor while increasing that of capital could account for this. However, the few studies that have looked at SBTC in India, find it to be less in evidence than capital-skill complementarity (Berman et al. (2005), Berman and Machin (2000)). In addition, the data showing a fall in the relative cost of capital is very clear (Sen and Das (2014)). In fact, it fell so much that despite the near doubling of capital intensity, the relative income share of capital to labor fell (Leblebicioglu and Weinberger (2018)).

In summary, this tractable framework using a basic version of task based production ensures that formal firms are skill-selective, sustains a continuum of wages enabling the preference structure to play a fuller role, and provides a means of matching Indian data on the effects of capital cost shocks.

1.3.3 Firm Profits

Formal Firms

The marginal cost of producing a unit of a formal good involves performing each task $z \in \{0, z^F\}$, b^F times. This is given by Equation (1.11).

$$MC^F = b^F \left(c_k^F \int_0^{z^*} \frac{1}{\psi_k(z)} dz + \int_{z^*}^{z^F} \frac{w(\phi^{-1}(z))(1+t_w)}{\psi_w(\phi^{-1}(z), z)} dz \right) \tag{1.11}$$

This is simply an aggregation of the marginal costs of completing all the necessary tasks, with each individual firm taking the rate of capital and the wage function as given. Post this, demand and profitability follow the standard equations seen in a CES setup with monopolistic competition and heterogeneous firms. This is particurlay familiar in the trade literature following Melitz (2003). If E^F is the total expenditure on formal goods, and $\alpha \sim G(\alpha, \theta)$ is the demand draw of a firm that has chosen to be in the formal sector, then the demand it enjoys is given by $q^F(\alpha)$

$$q^F(\alpha) = \alpha E^F P^{F\sigma^F - 1} \left(p^F\right)^{-\sigma^F}$$

While the quality of a formal good sold is dependent on the demand draw, the price is not. This is because the marginal cost of making a formal good is the same for

all formal firms, and so is the Dixit-Stiglitz markup. Added to that, is a sales tax t_s levied on all firms that choose to be formal. The formal composite good price index derives from the usual CES aggregation.

$$p^F = \frac{\sigma^F(1+t_s)}{\sigma^F - 1} MC^F$$

$$P^F = \left(M^F \left(p^F\right)^{1-\sigma^F} \int_{\alpha^*}^{\infty} \alpha \mu^F(\alpha) d\alpha \right)^{\frac{1}{1-\sigma^F}} = p^F \left(M^F \int_{\alpha^*}^{\infty} \alpha \mu^F(\alpha) d\alpha \right)^{\frac{1}{1-\sigma^F}} \quad (1.12)$$

Where M^F is the mass of formal firms in equilibrium, and $\mu^F(\alpha) = \frac{g(\alpha)}{1-G(\alpha^*)}$ is the distribution of the demand draws of those firms that have chosen to be formal. The domestic profit of a formal firm under autarky (the open economy version follows later) is given by Equation (1.13).

$$\pi^F(\alpha) = (1-t_c) \left(q^F(\alpha) \frac{MC^F}{\sigma^F - 1} - S^F \right) \quad (1.13)$$

Here, t_c is an additional corporate tax levied on firm profits and S^F is a fixed cost of establishment. This fixed cost is seen to combine both the setup costs that go into creating a production infrastructure for higher quality goods, as well the fixed costs of formality (registration costs and so on). This will imply that $S^F > S^I$. It's important to note that the formal sector price index affects demand both directly and by changing the relative consumer spending on formal and informal composite goods.

Informal Firms

Informal firms optimally use only labor for producing their goods, and all the labor they use is able to perform tasks with productivity A_w. To produce an informal good, tasks in the range $z \in \{0, z^I\}$ need to be completed b^I times. Consequently, the marginal cost of producing an informal good is very simply given by $MC^I = \frac{w^I b^I z^I}{A_w}$. In order for an informal firm to make a quantity q of goods, a measure of labor $l = \frac{q b^I z^I}{A_w}$ is required.

From the section on India's institutional context, it is known that Indian law holds illegal those informal firms with greater than 10 employees. In keeping with the literature (Amirapu and Gechter (2017)), I will use an escalating penalty that kicks off at this threshold, denoted by $\bar{l}$. The penalty will be given by the function

$\Upsilon(l-\bar{l})$, which is twice differentiable, increasing in l and convex. This penalty is seen to reflect an increasing chance of discovery and punitive action by the government (e.g. Ulyssea (2018)). There are two possible margins along which an informal firm with sufficient demand to seek more than $\bar{l}$ workers will respond. One is to exceed $\bar{l}$ in employment and charge a higher price to compensate. The other is to not exceed $\bar{l}$, and employ some capital to produce more with the same measure of labor. It's complex to have both in play, and not particularly useful. I will therefore assume that the wedge d which raises the cost of capital for informal firms over that faced by formal firms ($c_k^I = c_k^F + d$), is high enough to avoid this being profitable. The profit of an informal firm is given by Equation (1.14).

$$\begin{aligned} \pi^I(\alpha) &= max_{p^I}(p^I - MC^I)q^I(\alpha) - S^I - 1(l > \bar{l})\Upsilon(l-\bar{l}) \qquad s.t \\ l &= \frac{q^I(\alpha)b^I z^I}{A_w} \end{aligned} \tag{1.14}$$

From this, the price charged by an informal firm with demand draw α is given by Equation (1.15).

$$p^I(\alpha) = \begin{cases} \frac{\sigma^I}{\sigma-1}MC^I \quad if \quad q^I(\alpha) \leq \frac{A_w\bar{l}}{b^I z^I} \\ \\ \frac{\sigma^I}{\sigma-1}\left(MC^I + \frac{b^I z^I}{A_w}\Upsilon'(l(q^I)-\bar{l})\right) \quad if \quad q^I(\alpha) > \frac{A_w\bar{l}}{b^I z^I} \end{cases} \tag{1.15}$$

Where $q^I(\alpha) = \alpha E^I P^{I^{\sigma^I-1}} p^I(\alpha)^{-\sigma^I}$. Note that informal firms are paying neither a sales tax, nor a corporate tax, nor the cost of additional worker benefits. The informal price index is given by

$$P^I = \left(M^I \int_{\bar{\alpha}}^{\alpha^*} \alpha p^I(\alpha)^{1-\sigma^I} \mu^I(\alpha) d\alpha\right)^{\frac{1}{1-\sigma^I}} \tag{1.16}$$

Where M^I is the mass of informal firms, and $\mu^I(\alpha) = \frac{g(\alpha)}{G(\alpha^*)-G(\bar{\alpha})}$ is the distribution of α's conditional on the firms having chosen to be informal.

Firm Choice

In most traditional models of informality, an escalating penalty with size if a firm chooses to be informal is the only factor compelling firms with higher productivity/demand draws to choose to be formal. In this model, it is one of two reasons. We have that $S^F > S^I$ and $\sigma^F < \sigma^I$. Even though formal firms have to pay additional taxes, the relative value of σ^F and σ^I is such that formal firms make a higher variable profit on sales of their good than informal firms. However, informal firms have a lower fixed cost. Even without the regulatory penalty $1(l > \bar{l})\Upsilon(l - \bar{l})$, larger firms would choose to be formal. In fact, in equilibrium, $\Upsilon(l - \bar{l})$ is not relevant because it doesn't bind on any informal firm. Firms stop being informal before they even reach the size $\bar{l}$, which is consistent with the Indian data showing a large measure of formal manufacturing firms of size less than$\bar{l}$ (Amirapu and Gechter (2017)).

It is clear that there is a cutoff value of the demand draw, α^* above which firms will choose to be formal, and that is given by the following

$$\pi^I(\alpha^*) = \pi^F(\alpha^*)$$

Given the fixed cost of forming a firm and starting operations (even the lower costs associated with operating informally) there is also a cutoff value of the demand draw $\bar{\alpha}$ below which firms will choose not to enter production at all.

$$\pi^I(\bar{\alpha}) = 0$$

and $\bar{\alpha} < \alpha^*$

1.3.4 Autarky Equilibrium

If M_E is the mass of firms which enter (as determined by a free entry condition), then the mass of formal and informal firms in operation is given by $M^F = M_E(1 - G(\alpha^*))$ and $M^I = M_E(G(\alpha^*) - G(\bar{\alpha}))$ respectively. Labour market clearing in the higher skill segment which gets employed in formal firms is already incorporated into Equation 1.8. The market clearing condition for the residual low skill segment ($s < s^*$) that gets hired by informal firms is given by Equation (1.17).

$$\bar{L}\left(H(s_{hi}) - H(s^*)\right) = M^I \int_{\bar{\alpha}}^{\alpha^*} \frac{q^I(\alpha) b^I z^I}{A_w} \mu^I(\alpha) d\alpha \tag{1.17}$$

The capital used by a formal firm with demand draw α is given by $k^F(\alpha)$

$$k^F(\alpha|\alpha \geq \alpha^*) = q^F(\alpha) \int_0^{z^*} \frac{b^F}{\psi_k(z)} dz$$

I assume there is a supply $\bar{K}$ of capital in the domestic economy and this equals the sum total of all the capital used by formal firms.

$$\bar{K} = M^F \int_{\alpha^*}^{\infty} k^F(\alpha)\mu^F(\alpha)d\alpha \tag{1.18}$$

The total economy wide earnings accruing to capital are given by C_K

$$C_K = c_k^F \bar{K}$$

Total wages paid to all workers in the economy is

$$W = \bar{L} \int_{s_{low}}^{s_{hi}} w(s)h(s)ds$$

Taxes which are collected by the government from formal firms include corporate taxes, worker welfare contributions and sales taxes. These total up to T.

$$T = t_c M^F \int_{\alpha^*}^{\infty} \left[q^F(\alpha) \frac{MC^F}{\sigma^F - 1} - S^F \right] \mu^F(\alpha)d\alpha + t_w W + \frac{t_s E^F}{1 + t_s} \tag{1.19}$$

The total profits of all firms in the economy are

$$\Pi = M^I \int_0^{\alpha^*} \pi^I(\alpha)\mu^I(\alpha)d\alpha + M^F \int_{\alpha^*}^{\infty} \pi^F(\alpha)\mu^F(\alpha)d\alpha$$

I assume that ownership of capital and firms are proportional to the basic wage (wealthier people invest more), and therefore the returns (earnings accruing to capital and total profits of all operating firms) are distributed proportionally. Government benefits are distributed lumpsum to everyone. This results in an augmented wage, given by

$$\hat{w}(s) = w(s) \left(1 + \frac{C_K + \Pi}{W} \right) + \frac{T}{\bar{L}} \tag{1.20}$$

Total expenditure on formal and informal goods (absent of an adjustment for the fixed costs that firms pay) is given by

$$E^F = \bar{L}P^F \int_{s_{low}}^{s_{hi}} Q^F(\hat{w}(s))h(s)ds \tag{1.21}$$
$$E^I = \bar{L}P^I \int_{s_{low}}^{s_{hi}} Q^I(\hat{w}(s))h(s)ds$$

To close things off, the free entry condition is

$$\int_{\bar{\alpha}}^{\alpha^*} \pi^I(\alpha)g(\alpha)d\alpha + \int_{\alpha^*}^{\infty} \pi^F(\alpha)g(\alpha)d\alpha = S_E \tag{1.22}$$

1.3.5 Open Economy

Trade takes place with a second country which is deemed to the Rest of the World (RoW). The focus is on the effect that trading with RoW has on home, and not the other way around. RoW is much larger, and the effect of the entry of home based companies into it will have a minimal impact on the price index of the RoW. Taking this to its logical extreme, I assume that it has no impact, thereby treating home as a small open economy. In effect, RoW presents a price index to home based companies which they take for granted.

Informal firms have very little direct engagement in international trade. They don't have the scale to overcome the entry costs, the expertise to navigate new markets, or the desire to go through the financial and bureaucratic requirements of getting an import-export license, and the clearances to operate foreign exchange approved account. The top 0.6% of firms by size account for 87% of all exports from India (Indian Economic Survey 2018). Given this, and fact that the impact of India's trade liberalisation on the rest of the world is likely a second order effect, it's a needless complication to model RoW as a dual economy. RoW is modelled as an all-formal economy that presents itself as a new source of demand for formal home based firms. It also serves as the origin of foreign formal companies that enter the home market.

I will assume that the demand draw of companies remains the same across both countries, and RoW based firms get their demand draw from the same distribution as the home based firms. A home based firm pays a fixed cost of S_{HRoW} to access

the RoW, and a foreign firm pays S_{RoWH} to go the other way. An iceberg cost of $\tau_{HRoW} = \tau_{RoWH} = \tau$ applies in both directions. These costs imply a demand draw threshold of $\bar{\alpha}_{HRoW} \geq \alpha^*_H$ for home based companies, and $\bar{\alpha}_{RoWH}$ for RoW companies to engage in exporting. Prices of goods sold by formal home based countries in RoW is given by $p^F_{HRoW} = \tau p^F_H$, and the demand for the goods sold by a home based company in RoW given by

$$q^F_{HRoW}(\alpha) = \alpha E_{RoW} P^{\sigma^F - 1}_{RoW} \left(p^F_{HRoW}\right)^{-\sigma^F} \tag{1.23}$$

A symmetric equation applies for RoW based companies entering the home market with $p_{RoWH} = \tau p_{RoW}$. The price index of the formal composite good at home now includes the imports and becomes

$$P^F_H = \left(M^F_H \left(p^F_H\right)^{1-\sigma^F} \int_{\alpha^*_H}^{\infty} \alpha \mu^F_H(\alpha) d\alpha + M_{RoW} \left(p_{RoWH}\right)^{1-\sigma^F} \int_{\bar{\alpha}_{RoWH}}^{\infty} \alpha \mu_{RoW}(\alpha) d\alpha \right)^{\frac{1}{1-\sigma^F}} \tag{1.24}$$

The total quantity produced by a home based formal firm which exports is given by $q^F_H(\alpha) + \tau q^F_{HRoW}(\alpha)$, and total profits are given by Equation (1.25).

$$\pi^F(\alpha | \alpha > \bar{\alpha}_{HRoW}) = (1 - t_c) \left(\left(q^F_H(\alpha) + \tau q^F_{HRoW}(\alpha)\right) \frac{MC^F}{\sigma^F - 1} - S^F_H - S_{HRoW} \right) \tag{1.25}$$

Note that the formal exporting firm is being taxed on its cumulative profit (both from home sales and exports). For simplicity, I take it that all taxes go to the government in the country where the tax is collected.

Capital in the Open Economy

In India, the investment rate in foreign capital goods grew 63% as a result of trade liberalisation (Kandilov and Leblebicioglu (2016)). Both input and output tariffs were dramatically cut through the 90's and early 00's, and the rate of growth of capital goods imports exceeded that of overall manufacturing trade by about 40%. This is important to consider in the context of this model, since the rapid rise in capital intensity in the decade that followed trade liberalisation is a key part of the mechanism.

In keeping with the view of India being a small open economy, firms in the home country will be allowed to access capital from the international market at a constant rate r_{RoW}. In other words, borrowing by home has no effect on the international price of capital. Capital borrowed from overseas is not perfectly substitutable for capital originating at home, and the two are aggregated via a CES function. This is a previously employed formulation for dealing with imported capital (Leblebicioglu and Weinberger (2018), Kandilov et al. (2019)). It also agrees with findings that input imports into India following trade liberalisation were qualitatively different from existing inputs (Goldberg et al. (2009)).

$$k = \left(\beta k_{RoW}{}^{\frac{\sigma_k - 1}{\sigma_k}} + (1-\beta) k_H{}^{\frac{\sigma_k - 1}{\sigma_k}} \right)^{\frac{\sigma_k}{\sigma_k - 1}} \tag{1.26}$$

Either form of capital is offered to informal firms at a premium d. I assume that the same iceberg cost applies for capital goods as well as final goods. Both tariffs were brought down simultaneously when India embarked on trade liberalisation. This implies that the costs of capital at home are given by

$$c_k^F = \left(\beta^{\sigma_k} (\tau r_{RoW})^{1-\sigma_k} + (1-\beta)^{\sigma_k} r_H^{1-\sigma_k} \right)^{\frac{1}{1-\sigma_k}}$$
$$c_k^I = \left(\beta^{\sigma_k} (\tau r_{RoW} + d)^{1-\sigma_k} + (1-\beta)^{\sigma_k} (r_H + d)^{1-\sigma_k} \right)^{\frac{1}{1-\sigma_k}}$$

r_H is determined in equilibrium by the supply of home based capital $\bar{K}_H$ being cleared. r_{RoW} is considered to be the numeraire and set to 1.

1.4 Calibration and Estimation

I use both the data from 1999-00 as well as 2010-11 to calibrate both the beginning and the end of the observation period examined in this paper. In both cases, the sources of variation used are the same.

1.4.1 Statutory Parameters

Certain parameters correspond to statutory or institutional values in the data. These are the three tax rates, t_c, t_s and t_w, as well as $\bar{l}$, which is the employee cap where penalties kick in for informal firms. t_c is matched to the effective corporate tax rate in

India that year. This is different from the nominal corporate tax rate, because there are numerous exemptions and deductions that corporations can use to reduce their actual tax outgo on profits. t_s corresponds to the aggregate average rate of excise and sales taxes collected by the union as well as state governments in India. t_w is harder to match to any one specific institutional value. This is the extra cost of employing labor that formal firms incur over and above their informal counterparts. The Provident Funds Act, 1952 mandates that 12% of the employee's wage be contributed by the employer towards the employees provident fund, and The Payment of Bonus Act, 1965 mandates that a profitable manufacturing firm pay a minimum of 8.33% of wages as a bonus to employees earning less than a specified threshold. Both these acts are applicable to firms with greater than 20 employees. Incorporating both, I choose a value of $t_w = 0.2$. $\bar{l} = 10$ in accordance with the data.

Table 1.4: Values of Statutory Parameters

	1999-00	2010-11
t_c	0.2207	0.2410
t_s	0.1545	0.1476
t_w	0.2	0.2
$\bar{l}$	10	10

1.4.2 Normalized and Pegged Parameters

Several of the moments to be used in the subsections to follow are ratio/relative moments comparing values between formal firms and their informal peers, or between labor and capital. When there are two parameters which are counterparts in this respect, one of them will need to be normalized. b^F will influence the average price of the formal composite good relative to the informal one given b^I, and so I set $b^I = 1$. S_H^F will influence the fraction of firms that choose to be formal given a set value of S_H^I, and so $S_H^I = 1$. $\bar{z}_k$ will cause variations in the labor share of income given a value of $\bar{z}_w$, and so I set $\bar{z}_w = 1$. $\bar{z}_w$ though does limit z^I because, z^I is set with the constraint $z^I \leq \bar{z}_w$ in mind. Since all workers in informal firms get the same wage, the choice of z^I has no direct impact on the wage structure beyond s^* except via weaker general equilibrium effects that are hard to target. Relative to the value of

z^F, it does impact the ratio of prices of goods that are formally made vis-a-vis those that are informally made, however, b^F does the same. Taking this into account, I set $z^I = \bar{z}_w = 1$.

Given Equation (1.5), the productivity of labor, which determines the wage schedule via Equation (1.9), depends on level of skill s relative to the task z to which it is assigned. We have to pin down either the scale of s, or that of z, because they only result in observable variation relative to each other. I set $s_{low} = 0.5$ and $s_{hi} = 4$.

The three parameters which anchor the consumer demand function given by Equation (1.1) are ρ_u, δ and $\bar{C}$. Looking at Figure 1.8, the level of income at which consumers start to consume the formally produced composite good is controlled by $\bar{C}$. Once $\bar{C}$ is set, the rate at which the consumption of the informal good reduces (in other words the income elasticity of expenditure share) is driven by either δ or ρ_u. Within the scope of the data used in this paper, there is no separate source of variation that would allow the identification of both δ and ρ_u. Given data on how relative consumption of formal and informal goods responds to changes in their relative prices, as well as to changes in consumer income, both could be identified. Here, information on expenditure share/quality elasticity can only help pin down one given the other. I set $\rho_u = -1$.

1.4.3 Estimated Parameters

Independently Identified Parameters

θ, which is the pareto shape parameter that determines the distribution of demand draws, is calibrated to target the first and second order moments of the distribution of GVA across formal firms in India. With using informal firm data for this purpose, there would be concerns about the 10 person threshold distorting the shape of the distribution. Since the truncated pareto distribution of demand draws of firms which choose to be formal is also a Pareto with the same shape parameter, there is no loss in doing this. I find $\theta = 3.06$. σ^F, which determines the markup that formal firms charge, targets the average pre-tax profits to GVA of formal firms in the data, giving a figure of $\sigma^F = 3.6$. For informal firms, this figure is harder to arrive at, because the data cannot provide a clear idea of an informal firm's true labor costs.

Unlike registered firms, informal firms do not operate as entities that are inde-

pendent of their owners. The surplus from the enterprise constitutes the earnings of the owner, and for most firms, the owner provides the most important component of the labor used in production. Own account enterprises, which is to say informal enterprises that do not hire any paid labor on a permanent basis, constitute 84% of all informal manufacturing enterprises in India. Since the informal firm data doesn't record the "wages" paid to the owner or his/her family, I do not know the labor cost involved in production, and cannot estimate profits. I therefore turn to the literature for estimates from other countries with a similar level of development, and a high prevalence of informality. Medvedeva and Oviedo (2016) look at data from Ecuador, and find that formal firms in general have 2-3 times the profitability of informal firms. Although they too face the problem of the owners wage being subsumed in profits, they look at a sample of larger informal firms where hired workers constitute a more dominant part of the total labor supplied. In line with this, I choose $\sigma^I = 8.5$.

While the upper and lower limits of the skill range are pinned down, the distribution of skill $H(s)$ is yet to be specified. Based on data from the NSSO's Employment and Unemployment Survey, I segment the workforce into 4 groups by maximum educational attainment. These are those who are illiterate or have below primary education, those with primary and middle school education, those with secondary and higher secondary education, and finally those with tertiary education or more. The distributions of skill conditional on each of these four attainments are given by $o_{BP}(s)$, $o_{PM}(s)$, $o_{SH}(s)$ and $o_{TE}(s)$ respectively. All distributions are assumed to be truncated Weibull distributions with the same fixed scale parameter. The choice of using a Weibull distribution is made because when truncated, it can be both positively and negatively skewed. Most of those with low educational attainment work in informal firms. Therefore $o_{BP}(s)$ and $o_{PM}(s)$ have to be positively skewed with the bulk of the density below s^*. On the other hand, the majority of those with tertiary educational attainment are employed in formal firms. So $o_{TE}(s)$ has to be negatively skewed, with most of the distribution above s^*. I calibrate the 4 shape parameters with 4 target conditions which are the conditional probabilities of each of these four educational ending up formally employed. The overall distribution of skills $h(s)$ is given by

$$h(s) = \frac{\bar{L}_{BP}}{\bar{L}} o_{BP}(s) + \frac{\bar{L}_{PM}}{\bar{L}} o_{PM}(s) + \frac{\bar{L}_{SH}}{\bar{L}} o_{SH}(s) + \frac{\bar{L}_{TE}}{\bar{L}} o_{TE}(s) \tag{1.27}$$

Jointly Identified Parameters

$\bar{C}, \delta, z^F, S_H^F, \tau, S_{HRoW}^F, A_k, \bar{K}, \beta_H, \sigma_k, \bar{z}_k$ and b^F still remain. In total there are 12 parameters which will chase 13 moments, and so these parameters are slightly over-identified. I minimize the percentage deviation of model moments from their real world counterparts, in a method of moments setup with equal weights. There is some tension between the moment conditions, but the eventual fit is fairly close (Table 1.5). For example, changing $\bar{C}$ with every other parameter kept would change relative demand for formal and informal goods. Because of that, it will also alter the fraction of workers who are informally employed, an independent second moment.

δ is isolated using the observed value of quality elasticity (which is directly tied to the income elasticity of expenditure share). The unit value of goods purchased by consumers based on their income, given by $v(\hat{w})\frac{P^F Q^F + P^I Q^I}{Q^F + Q^I}$, can be derived from Equation (1.3) and (1.4). From that, the quality elasticity $\frac{dv(\hat{w})}{d\hat{w}}\frac{\hat{w}}{v}$ can be computed

$$\frac{dv(\hat{w})}{d\hat{w}}\frac{\hat{w}}{v} = \begin{cases} 0 \quad if \quad \hat{w} \leq P^I\bar{C} \\ \frac{(P^F - P^I)\bar{C}}{(P^F - P^I)\bar{C} + \frac{\delta}{\Lambda}\hat{w}} \quad if \quad P^I\bar{C} \leq \hat{w} < \frac{\Lambda P^F \bar{C}}{\Lambda - \delta} \\ 0 \quad if \quad w \geq \frac{\Lambda P^F \bar{C}}{\Lambda - \delta} \end{cases} \tag{1.28}$$

Quality elasticity takes a non-zero value only in the income region where consumers are transitioning from the lower priced informal good to its higher priced formal counterpart. The value of quality elasticity in this region is decreasing in δ, and increasing in $\Lambda(P^F, P^I, \rho_u)$. $\Lambda(P^F, P^I, \rho_u)$ in turn is decreasing in ρ_u. A higher δ and a higher ρ_u [12] are therefore both associated with lower quality elasticity in this range.

Intuitively, the reason is as follows. A higher δ implies that consuming the same amount of formal good results in higher quality based satisfaction δQ^F. As seen in Equation (1.1), this is a net complement to the surplus above the subsistence threshold given by $Q^F + Q^I - \bar{C}$, and it is cheaper to increase this surplus by consuming more of the informally made good. A higher ρ_u makes the surplus and the quality based

[12] Recall that $\rho_u < 0$, and so a higher ρ_u is one that is closer to 0

satisfaction more substitutable, once again leading to greater consumption of the informally made good at any income level in this transition range. In either case, there is a slower transition to a zero informal expenditure share, and a lower quality elasticity. The choice is to fix ρ_u, and estimate δ in relation to that chosen value. Unlike the most of the data which is either from 1999-00 or 2010-11 depending on which end of the decade is being calibrated to, all price related data is from 2005-06. This is the only year for which informal manufacturing firm prices can be computed, as noted in the data section. In addition to δ this affects b^F which will target the ratio of prices of the formal good to the informal one.

If z^F is increased, that implies more tasks being added at the high end of the formal task spectrum. For any value of s in this region, the assignment function $\phi(s)$ shifts upwards, assigning people of every skill in $s \in (s^*, s_{hi}]$ to more complex tasks to compensate for the addition of these tasks. Substituting (1.5), in (1.9), the differential equation which determines the wage schedule beyond s^* is given below. An increase in $\phi(s)$ for a given value of s increases the numerator, and decreases the denominator of the RHS, making wages go up more steeply with skill. This is shown graphically in Figure 1.12c).

$$\frac{dw(s)}{ds} = w(s)\frac{(\phi(s) - \bar{z}_w)}{s(s - (\phi(s) - \bar{z}_w))} \quad if \quad s^* \leq s \leq s_{hi}$$

I can therefore isolate z^F using the ratio of average wages paid to formal workers, to that of informal workers. Unlike some other countries, I cannot source employer-employee matched data for India, and can only observe such aggregate wage moments.

S_H^F targets the fraction of all firms which end up being in the formal sector. S_{HRoW}^F, which is the other fixed cost involved, targets the fraction of formal firms that engage in exporting. ASI and NSSO data doesn't deal with exports, but other papers have used the Prowess database from the CMIE (Center for Monitoring the Indian Economy) to find that about 40% of the firms in CMIE data are exporters in the year 2006 (Ranjan and Raychaudhuri (2011)). This is almost certainly an overestimate, because the CMIE survey focuses only on large and medium sized formal firms. This paper targets an exporter fraction of 30% for. I assume for simplicity that $S_{RoWH} = S_{HRoW}^F$. Also using CMIE data, Cheung and Sengupta (2013) find that in 2000, exporting firms had an exports/sales ratio of 26%. I use this for the estimate of

τ in 1999-00. τ in 2010-11 will be determined by the increase in manufacturing trade relative to 1999-00. β_H is identified using the share of capital goods imports in total manufactured goods trade, and σ_k is identified using the change in this share with a reduction in the iceberg cost between 1999-00 and 2010-11.

Table 1.5: Select Model Moments compared with Data Moments

	1999-00	
	Model	Data/Target
Fraction of informal employment	76.99%	77.00%
Informal share of manuf. GDP	30.90%	32.82%
Ratio of avg formal to informal wages	3.108	3.105
Fraction of formal firms	1.06%	0.91%
Fraction of exporting formal firms	29.75%	30%
Exports to tot sales of exporting firms	0.2638	0.2592
Adjusted labor share	70.32%	71.43%
Capital intensity	0.4864	0.4917
Domestic capital goods value/manuf. GDP	11.48%	11.80%
Capital goods imports share in manuf. trade	14.32%	14.75%
Ratio of formal to informal prices	2.90	2.90
Quality elasticity	0.5582	0.5395

$\bar{z}_k$, A_k and $\bar{K}$ are identified using the adjusted labor share, capital intensity, and the share of domestic capital goods in manufacturing output. Adjusted labor share, is the labor share of income computed sans any intermediates (because there aren't any in the model). It is the share of GVA net of profits, taxes, and other non-capital, non labor outgoings that goes towards labor on an annual basis. Raising $\bar{z}_k$ increases the productivity of capital at more complex tasks making capital a viable choice for doing them, but doesn't change its productivity at less complex tasks. Increasing A_k improves proportionally capital's productivity at all tasks, and changing $\bar{K}$ changes the endowment of domestically available capital. All changes will of course have general equilibrium effects on other moments. The match between the data and model moments for 1999-00 (which is what will be used in the counterfactual exercises in

Section 5), is given in Table 1.5.

1.5 Counterfactual Experiments

The model as showcased in Section 3, does not include non-manufacturing sectors. Most structural models in trade and development are built this way, because just like in India, microdata on manufacturing tends to be much more widely available than any other sector. This model however, seriously considers non-homothetic demand. In this context, changes in the overall income distribution, including those not working in manufacturing, will affect the relative demand for informal and formal manufactured goods. Over the decade in question, both the income distribution among manufacturing workers, and the broader population shifted to become more unequal, the latter by much more.

Section 6 tackles this by implanting an exogenous measure of consumers whose income distribution matches the rest of India's population, re-calibrating the model and estimating the impact the demand and supply channels. This section should be viewed as a series of illustrative counterfactuals demonstrating the directional and comparative impact of various shocks in the general equilibrium framework of the all-manufacturing economy while allowing all incomes to be endogenously determined.

1.5.1 Trade Liberalisation

In performing this counterfactual, I lower the value of the iceberg cost on manufactured goods from $\tau = 2.02$ which is the benchmark value estimated in the previous section, to $\tau = 1.71$ which achieves the 43% increase in manufacturing trade as a fraction of output seen in the data. In Table 1.6, I show some of the more interesting moments which help illustrate the outcome of this counterfactual.

Table 1.6: Benchmark vs Counterfactual Moments: Trade Liberalisation

	Benchmark	Counterfactual
Fraction of informal employment	76.99%	77.01%
Informal share of manuf. GDP	30.90%	28.56%
Ratio of avg formal to informal wages	3.108	3.46
Fraction of formal firms	1.06%	1.13%
Exports to tot sales of exporting firms	0.2638	0.3612
Adjusted labor share	70.32%	68.93%
Capital intensity	0.4864	0.5796
Capital goods imports share in manuf. trade	14.32%	20.63%
Manuf. trade to value added (rel to 1999-00)	1	1.46
Ratio of formal to informal prices	2.90	3.03
Coefficient of var in income	0.598	0.648
Avg utility/benchmark bottom 70%	1	1.029
Avg utility/benchmark next 20%	1	1.078
Avg utility/benchmark top 10%	1	1.085
Avg utility relative to benchmark	1	1.065

The headline result is that while there is a welfare gain, particularly for the higher skill segment, there is no reduction in informal employment. In addition, there substantially higher inequality, indicated in both the ratio of formal to informal wages as well the overall coefficient of variation.

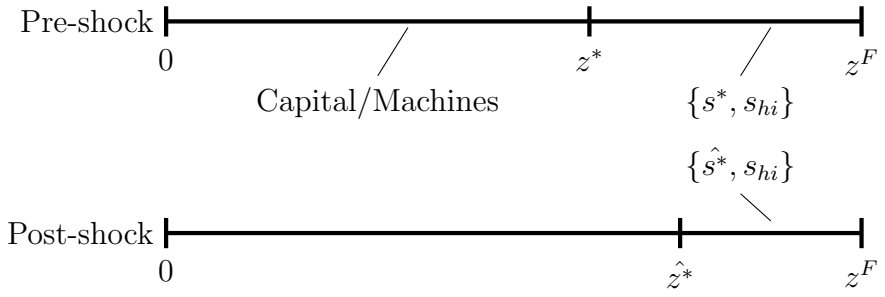
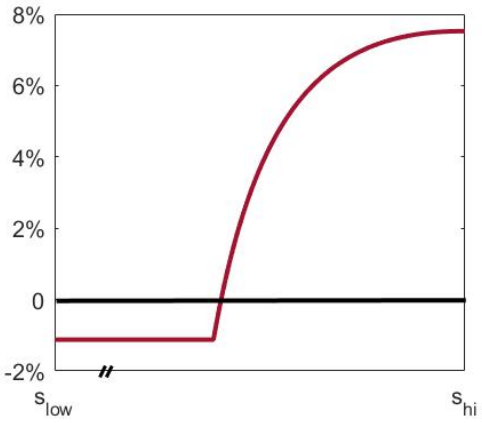
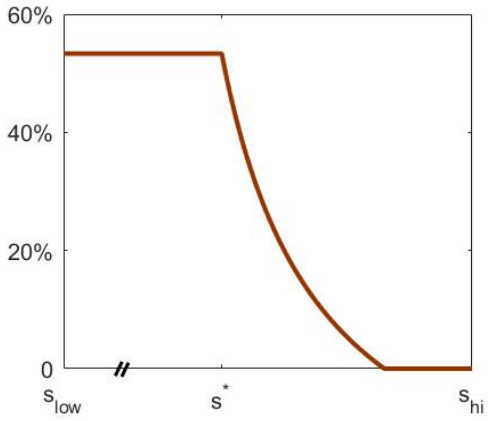


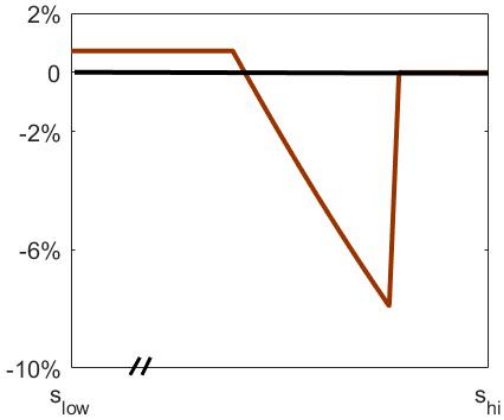
Figure 1.13: Effect of cheaper capital imports on formal firm task split



(a) Change in $\hat{w}(s)/P_H^F$ (quantity of composite formal good that a consumer can afford) vs skill (kink in axis)



(b) Pre-shock informal expenditure share plotted against skill (kink in axis)



(c) Change in quantity of informal good purchased (normalised by average informal good consumption) vs skill (kink in axis)

Figure 1.14: Various outcomes from the trade liberalisation shock as experienced by workers of heterogeneous skill. Kinks in the initial part of the x-axis are because those with skill between s_{low} and s^* who are informally employed, all have the same income and consume in the same manner.

Lowered trade barriers have an impact on both inputs and the final formal good. On the input side, there is a substantial jump in imports of capital goods which get cheaper, even greater than the overall increase in trade. The share of capital imports in overall manufacturing trade rises from 14% to 21%, pushing up capital intensity by

19%. This increase in the use of capital per unit labor in formal firms comes at the expense of the capital-labor threshold task in the task spectrum (z^*) shifting upwards, implying that capital does a greater portion of the tasks involved in producing formal goods (Figure 1.13). The flip side of this is that labor is now only used for more complex tasks on average, and the task assignment shifts upwards (like in Figure 1.12b), termed as *task upgrading*). In turn, this raises the skill premium among those formally employed, particularly benefiting the most skilled formal employees.

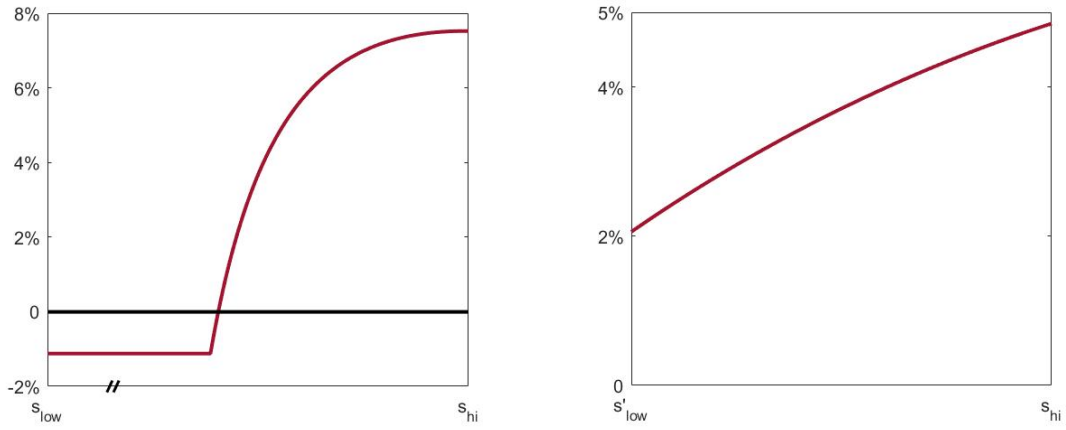
Counter-intuitively, the ratio of formal to informal composite good prices goes up from 2.90 to 3.03 even as the capital used in formal production gets cheaper. This is in fact not abnormal at all in a task based production framework, because the extent of the rise in skill premiums is not restrained to be smaller in its impact than the fall in capital cost. The change in skill premium is driven by the change in task assignment, and decoupled from other determinants (Acemoglu and Restrepo (2020)). It drives up the ratio of average formal to informal wages, and with labor constituting a greater part of the input cost in formal firms in comparison to capital, this is sufficient to increase the cost of the formal good relative to the informal one. This combination of results implies that most of the real wage gain occurs among the highest skill workers already earning a high wage (Figure 1.14a)), and that the formal good gets less affordable for low skill/low income informal workers who do not benefit from trade liberalisation.

On the demand side, this group of high skilled workers who already earned high wages, already have a zero informal expenditure share for manufactured goods (Figure 1.14b)). Because their income elasticity of informal expenditure share is zero, their income gains do not contribute to reducing demand for informal goods (Figure 1.14c)). Such a reduction occurs only among workers of mid-tier of skill who see some modest gains in income as well have a non zero expenditure share elasticity.

In the general equilibrium framework of the model, the demand and supply side effects interact with each other. With regard to informality, both are muted. On the supply side, task upgrading restrains formal firms from lowering s^* and relaxing skill selectivity, because workers are now being used for more complex tasks on average. The greater formal output spurred by export demand and cheaper capital, is accomplished by using capital for more the production process, and reserving almost the same labor for more difficult tasks. On the demand side, the overall reduction

in demand for informal goods is negligible. The aggregate result is no increase in formalisation.

It's important to note that trade liberalisation still has an aggregate positive welfare effect. However, distributionally, this welfare gain is concentrated among the highest skill workers in formal employment. It leaves behind the class of workers in informal firms. It's interesting to compare this with what would happen if the entire population was skilled enough to function in an all-formal economy. In other words, how are the gains from trade affected by the presence of the informal sector in this model, and workers who cannot transition to the formal sector. To do this, I remove the informal sector, and the informal good from contention. All workers are formally employed, and therefore capital complements all of them. s_{low} is increased to the minimum level required to ensure that a worker with this skill can perform the task z^* in equilibrium (which earlier a worker of s^* performed). $\bar{C}$ is re-calibrated to allow us to start at the same level of average utility as the pre-shock dual economy. All other parameters are left unchanged. This economy without informality is now subjected to trade liberalisation of an equal measure (Figure 1.15).



(a) Change in $\hat{w}(s)/P_H^F$ in model with informality (kink in axis)

(b) Change in $\hat{w}(s)/P_H^F$ in model without informality

Figure 1.15: Various outcomes from the trade liberalisation shock as experienced by workers of heterogeneous skill

Unsurprisingly, the real income gains to trade liberalisation are clearly more widespread, but they are also greater in aggregate than what is seen in their dual economy coun-

terpart. Informality, and the presence of workers too unskilled to operate in formal firms, reduces the fractional gain in overall average utility by 20.5% and the gains in formal sector output by 42%.

1.5.2 Technology and Capital Supply

Two very similar shocks are examined in this sub-section, the first of which is to increase the productivity of capital A_k by 10%, and the second of which is to increase the available domestic supply of capital $\bar{K}$ by 10%. The first can be termed as skill biased technical change, and the second operates by lowering the cost of capital in equilibrium. Both shocks represent an expansion in the task-effective supply of capital, by which I mean the ability of the available capital to complete tasks. The former shock packs somewhat more punch than the latter, because it adds to the task-effective supply of both domestic and imported capital by 10%, while the latter only adds to the domestic component. If formal firms were to keep the allocation of tasks between capital and labor the same as before the shock, there would be a rise of even greater magnitude in the use of labor (because more of the lower skill workers available for hire would be needed given their lower productivity). Instead, employment in formal firms grow by just 1.67% and 1.15%; insufficient to significantly dent informal employment.

The same set of factors as those described in the trade liberalisation counterfactual come into play to attenuate the formal employment impact. On the supply side, capital displaces workers from less complex tasks, making it less economical for formal firms to use lower skilled workers in their workforce. On the demand side, the greatest income gains accrue to those who don't contribute to reducing overall expenditure on informally made goods in the economy.

Table 1.7: Benchmark vs Counterfactual Moments: Technology and Capital Supply Shocks

	Benchmark	Counterfactuals	
		Cap. Prod.	Cap. Supply
Fraction of informal employment	76.99%	76.61%	76.74%
Informal share of manuf. GDP	30.90%	27.69%	28.41%
Ratio of avg formal to informal wages	3.108	3.489	3.401
Fraction of formal firms	1.06%	1.23%	1.19%
Adjusted labor share	70.32%	69.94%	69.88%
Cap. intensity	0.4864	0.4763	0.5212
Dom. capital goods value/manuf. GDP	11.48%	12.23%	12.19%
Cap. goods imports share in manuf. trade	14.32%	13.78%	13.33%
Ratio of formal to informal prices	2.90	3.104	3.057
Coefficient of var in income	0.598	0.657	0.644
Avg utility/benchmark bottom 70%	1	1.054	1.042
Avg utility/benchmark next 20%	1	1.100	1.077
Avg utility/benchmark top 10%	1	1.119	1.090
Avg utility/benchmark overall	1	1.092	1.070

In these cases, as in the previous counterfactual simulating trade liberalisation, there is an increase in overall average utility, because the total economy wide production of formal goods increases. However, once again the combination of factors discussed isolates the benefit to the higher skill workers already in formal employ. For them, the lopsided wage growth works in their favor, and their purchasing power over the formal good increases. Meanwhile, no gain of such magnitude accrues to lower skilled workers who would more effectively use it to reduce their consumption of informally made goods. The visible pattern is one of growth in total output, coupled with increasing inequality and capital intensity [13], but no meaningful reduction in informal employment.

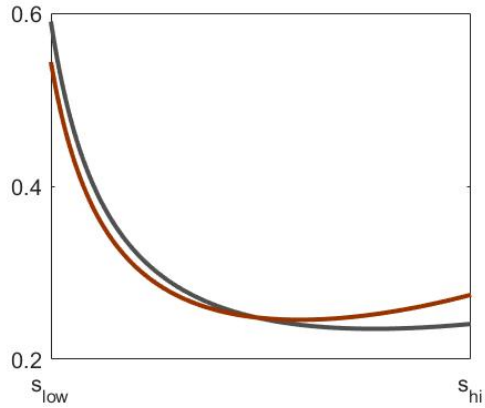
[13]Increased capital productivity does not increase the number of units of capital employed per unit of labor, it simply makes the existing capital do more tasks

1.5.3 Educational Composition

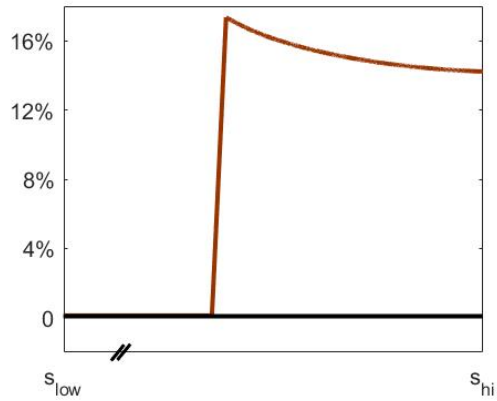
As explained in the data, the fraction of manufacturing workers who are formally employed is highly conditional on their educational group. If the educational composition improves, by sheer mechanical compositional effects, the overall share of formal employment should as well. For example, if a new educational workforce composition had 5% fewer workers with below primary education, and 5% more with tertiary education, the direct compositional effect would imply that an additional 2.2% of the workforce would be formally employed. This can be simulated in the model, where the distribution of skills conditional on education is retained but the distribution of the population between the educational categories is changed. However, as seen in Table 1.8, the fraction of informal employment falls by 3.5%. In other words, the shift from informal to formal employment is boosted by around 60% above the direct compositional effect.

Figure 1.16a) shows the overall change in the skill distribution that results from such a rejig in the educational composition of the workforce, with the result being an increased density of higher skill workers and a lowered density of low skill ones. Since higher skill workers are no longer as scarce, they do not need to be reserved for the most complex tasks in the same manner as they were. A worker of same skill is assigned a task of lower complexity than before the shock (*task downgrading*). This results in the range of tasks that labor performs in formal firms expanding to include tasks that capital was performing, and this is reflected in the lower capital intensity.

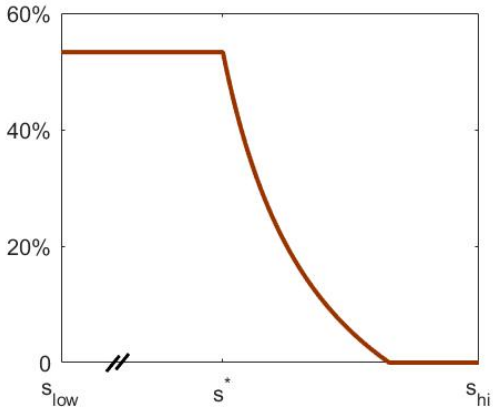
This allows formal firms to be less skill-selective, and lower s^*. The highest gain in wages now accrues to two groups of people. The low wage informal workers whose skill has now improved sufficiently for them to enter the formal sector, and the workers just below the earlier value of s^* whose skill has not improved, but who benefit from the lowered skill selectivity to now find formal employment as the formal sector expands. These are both categories of workers who were previously earning the low informal wage w_I, and have a negative informal expenditure share elasticity. The percentage gain in wages by skill levels is seen in Figure 1.16b). This graph represents clearly the gain for workers who retained the same skill before and after the shock. The gain for the former category of workers who move from left to right on the x-axis has to be computed relative to the pre-shock wage at their earlier level of skill.



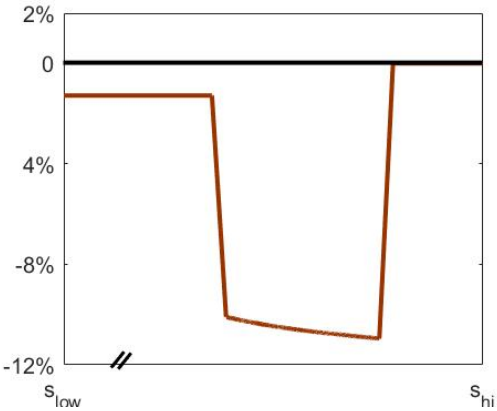
(a) Pre and post shock overall distribution of skill



(b) Change in $\hat{w}(s)/P_H^F$ (quantity of composite formal good that a consumer can afford) vs skill (kink in axis)



(c) Pre-shock informal expenditure share plotted against skill (kink in axis)



(d) Change in quantity of informal good purchased as a fraction of average informal good consumption vs skill (kink in axis)

Figure 1.16: Various outcomes from the skill composition shock as experienced by workers of heterogeneous skill

Of the workers whose skill remained the same, the highest fractional gains accrue to those in the middle of the skill spectrum newly entering formal employment. The consumption of the informally made good conditional on skill drops sharply in the middle (Figure 1.16d)) reflecting the gain in wages seen among these workers with a negative informal expenditure share elasticity. As overall demand for the informal good drops, the demand and supply side effects reinforce each other to drive down

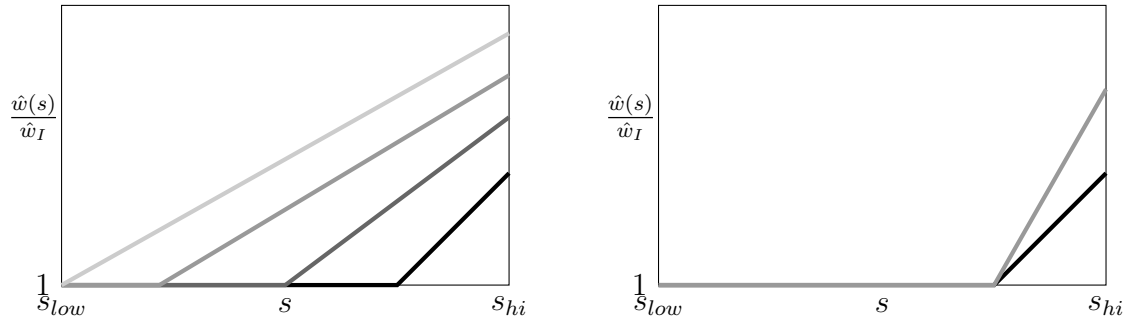
informal employment beyond what would be expected from direct compositional effects. This indicates that it would not be necessary to endow everyone with a high level of education in order to eliminate informality. Gains in formal employment will occur at a faster rate than the increase in the supply of high skilled workers.

Table 1.8: Benchmark vs Counterfactual Moments: Skill Composition change

	Benchmark	Counterfactual
Fraction of informal employment	76.99%	73.50%
Informal share of manuf. GDP	30.90%	23.84%
Ratio of avg formal to informal wages	3.108	3.72
Fraction of formal firms	1.06%	1.53%
Adjusted labor share	70.32%	71.30%
Capital intensity	0.4864	0.4454
Ratio of formal to informal prices	2.90	3.26
Coefficient of var in income	0.598	0.672
Avg utility/benchmark overall	1	1.230

There is less of an amplification when the increase in the supply of high skill workers is less pronounced. If 5% of the population with below primary education is educated to to a primary or middle school level, there is a 0.73% reduction of informality as opposed to the 0.47% we can expect with the direct compositional effect, which is an amplification of 0.26%.

Overall inequality rises here too, but in this case it is a Kuznets phenomenon, and will decline beyond a point if the educational composition continues to improve. The same can't be said for the increases in inequality that occur with trade liberalisation, capital supply improvements, and technological change. The difference between the two is shown in Figure 1.17.



(a) Behaviour of wages relative to the informal wage under skill composition upgrading

(b) Behaviour of wages relative to the informal wage under trade liberalisation/technology shocks

Figure 1.17: Illustration of change in wages by skill under skill composition upgrading vs trade liberalisation/technology shocks

Figure 1.17b) shows the manner in which wages relative to the informal wage level change in the case of trade liberalisation and technology shocks. There is no increase in the fraction of formal employment, which implies that s^* is almost unchanged, and the gain in wages accrues only to those already formally employed. Figure 1.17a) shows what is occurring with an upgrading of the educational composition, and what is going to continue to occur if the process continues in the same manner (in lightening shades of grey). There is a temporary increase in inequality as workers move from a segment with low by evenly distributed wages, to one with higher wages. While the ratio of average formal to informal wages increases as more workers shift to formal employ, informal workers constitute a smaller and smaller part of the overall workforce over time. Eventually real income growth from improvements in the educational composition will also be accompanied by lower inequality, and this could have a particularly strong demand effect in lowering informality.

1.5.4 Tax Reform

The model does not impose any taxes on informal firms. While informal firms in India are legally not required to pay corporate taxes or provide the same kinds of benefits to their employees as formal firms do, they are required to pay sales taxes. Given their small size and use of informal distribution channels, getting them to pay this has been a challenge. In India, this was discussed as a prime benefit of the move

to a value added tax regime for manufactured goods in 2005. The notion being that informal firms which were upstream suppliers to formal firms would be compelled by the latter to pay the value added tax, so that the larger downstream firm could obtain an input tax credit.

The self-policing nature of such a system would however, only work only on the minority of informal firms which have forward supply linkages with formal manufacturing firms. That is what is seen to have happened (Rios and Seetharam (2017)). Informal firms which sell to final consumers and are not integrated into a supply chain which requires input tax credits, are not likely to be incentivized to pay sales taxes. It is also possible, as De Paula and Scheinkman (2010) find in Brazil, that part of the effect of the imposition of a value added tax would be lost as informal firms that formerly made intermediate products for formal firms would shift to selling their products to other informal firms creating "informal chains" which don't pay the tax.

The model in this paper, does not incorporate intermediates, and consequently doesn't have supply chains. However, keeping in mind the possibility of successfully taxing informal firms on their sales, I take a look at a counterfactual where a 10% sales tax is imposed on all informal firms. The results depend quite a bit on how the additional revenue is spent by the government. If it is spent in a manner that adds an equal amount to every worker's real income, that implies a greater percentage gain to the income of low wage workers than high wage ones. There is a drop in informal manufacturing employment (Table 1.9), as well as an increase in the fraction of formal firms and overall average utility. First, the cost advantage of informal firms is eroded by having them pay a sales tax as well. Second, the increased provision of government benefits funded by this revenue increases the real income of the poorest consumers, and allows them to reduce their consumption of informal goods.

However, if for example, that additional revenue goes to only aiding the top 1% of income earners, the situation is not the same. The poorest consumers face an increased cost of informal goods from taxation, but no income gain to aid them in transitioning to formal good consumption. Overall average utility very marginally declines, concealing a larger decline for low skill/low income workers. A tax on informal goods is effectively a regressive tax because it taxes a good that low income consumers buy in greater proportion (Bachas et al. (2019)).

Table 1.9: Benchmark vs Counterfactual Moments: Tax levied on informal firms

	Benchmark	Counterfactuals	
		Equal Dist.	1% Dist.
Fraction of informal employment	76.99%	76.00%	77.34%
Fraction of formal firms	1.06%	1.34%	1.00%
Coefficient of var in income	0.598	0.622	0.758
Avg utility/benchmark bottom 70%	1	1.017	0.833
Avg utility/benchmark next 20%	1	1.118	0.923
Avg utility/benchmark top 10%	1	1.173	1.115
Avg utility/benchmark overall	1	1.124	0.966

This points to what the inclusion of product dualism does. Trying to penalise the informal sector, or erase its cost advantages does not always imply in equilibrium, a re-allocation of workers from the informal to the formal sector. This is slowed, both by the fact that the low skill workers employed in the informal sector are not favored by formal firms, and by the fact that incomes at the low end of the distribution have to rise enough to reduce the reliance on informal goods to meet consumption needs. Equally distributed government benefits can help with this, it augments real income by 34.1% for the poorest worker, and only by 6.1% for the wealthiest. India has a variety of government programs which add real income by paying additional wages for working on rural public infrastructure projects (MGNREGA), or by providing direct benefit transfers and subsidies on food and fuel, all of which allow families to spend more on consumer goods. It also provides public goods like security, which prevent households from having to divert their income to obtain the same by private means.

Table 1.10: Benchmark vs Counterfactual Moments: Tax relief for formal firms

	Benchmark	Counterfactual
Fraction of informal employment	76.99%	77.30%
Fraction of formal firms	1.06%	0.97%
Coefficient of var in income	0.598	0.621
Avg utility/benchmark bottom 70%	1	0.900
Avg utility/benchmark next 20%	1	0.984
Avg utility/benchmark top 10%	1	1.001
Avg utility/benchmark overall	1	0.965

If the government provides benefits are equally distributed, then cutting taxes on the formal sector which provides the revenue for such programs can have the opposite effect of driving formalisation. In Table 1.10, the corporate tax, the sales tax and the additional labor cost are each reduced by 20% of the original figure. This is a relevant counterfactual, because policies of this nature are either being discussed or have already been enacted. In 2020, India's government cut the base corporate tax from 30% to 22%, and the rate for new manufacturing firms from 25% to 15%. Although exemptions were eliminated at the same time, this still represented a sizable fall in effective corporate taxes. Reductions in the GST (goods and sales tax), which is India's combined national sales tax since 2017 are frequently discussed. A weakening of union power in India has effectively reduced the extent to which formal manufacturing firms are held to their obligation to provide worker benefits (Saini (2007)).

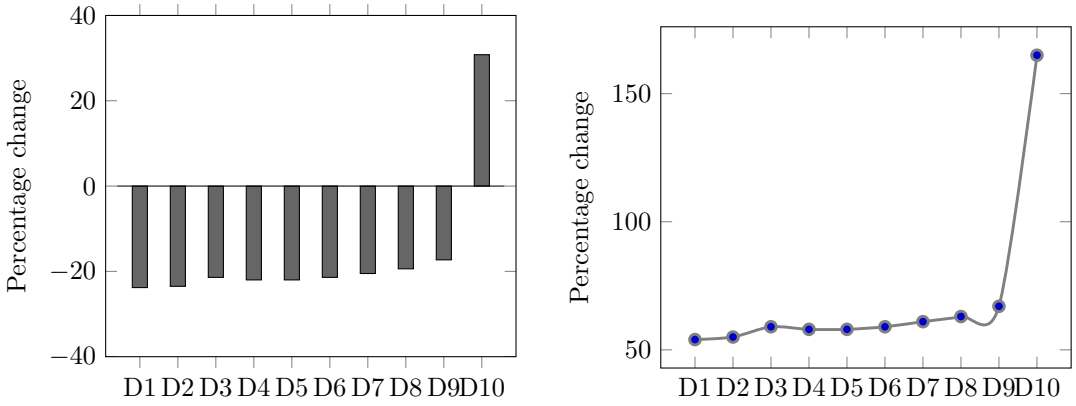
Given that these costs are levied only on formal firms, we might expect that formal firms would grow more profitable and competitive vis-a-vis their informal counterparts as a result of their easing, and formal sector output and employment might rise. However as we see in Table 1.10, this does not occur in this model.

The reduced government benefits from the loss of tax revenue disproportionately reduces the effective income of low paid workers, who retreat further into consuming inferior informal products. The increase in formal firm profits is mostly captured by wealthier consumers, whose income elasticity of informal expenditure is zero. In response, the total demand for formal goods, and the fraction of formal employment

declines, further reducing government revenues as a fraction of total output. It should be noted however, that this counterfactual does not speak to the effects of reducing non-tax regulatory compliance burdens on formal firms. It only alludes to the possible implications of reducing revenue generating taxes, and correspondingly reducing provisions for government benefits.

1.6 Dissecting the channels in India: 2000-2010

The counterfactual exercises seen so far illustrate the mechanisms of the model, and its directional responses to several shocks. The large chunk of the population ($\sim$ 93%) which is not employed in manufacturing, still consumes either informal or formal manufactured goods. Changes in manufacturing informality will therefore result from changes in the income distribution occurring among the entire population. Seen in Figure 1.18a), is data on India's income distribution taken from the World Inequality Database. The database is compiled using a combination of tax records, national accounts, and household consumption surveys.



(a) Change in share of national income by decile as a percentage of the 2000 share

(b) Change in average real income by decile

Figure 1.18: Evolution of income inequality in India over the period 2000-2010
Source: World Inequality Database and World Development Indicators

This income distribution looks very different between 2000 and 2010. As seen in Figure 1.18a), every other income decile of the population suffered a loss in their share of national income while the top decile gained. Superimposing this on the

growth in average PPP income as found in the World Bank's World Development Indicators, the change in average real income by decile is shown in Figure 1.18b). Without modelling the other sectors of the economy in detail, there is a need to incorporate this change in the income distribution while examining the impact of the demand channel over the period 2000-2010. In this section, I estimate the parameters separately to match the moments from 2000 and 2010 while doing that.

In the model, I insert an additional mass of consumers, whose income distribution can be exogenously specified. All consumers spend 16% of their income on manufactured goods. The additional mass of consumers who reflect those not employed in manufacturing, do not supply labor to the manufacturing sector. The model balances out because manufacturing workers cumulatively earn an amount equal to 16% of all the spending in the economy (manufacturing value added accounted for approximately 16% of GDP in both 2000 and 2010). The jointly identified parameters are determined via the same moments used earlier.

Table 1.11: Select Model Moments compared with Data Moments

	1999-00		2010-11	
	Model	Data	Model	Data
Frac. of inf. employment	76.99%	77.00%	76.33%	76.00%
Inf. share of manuf. GDP	32.70%	32.82%	29.26%	29.31%
Ratio of avg form. to inf. manuf. wages	3.112	3.105	3.590	3.581
Frac. of form. firms	1.03%	0.91%	1.265%	1.271%
Exports to tot sales of exporting firms	0.2641	0.2592	0.3561	NA
Manuf. goods trade/GDP rel. to 1999-00	1	1	1.49	1.43
Adjusted labor share	70.30%	71.43%	68.82%	71.42%
Cap. intensity	0.4930	0.4917	0.9132	0.9313
Domestic cap. goods value/manuf. GDP	11.47	11.80%	11.29%	11.80%
Cap. goods imports share in manuf. trade	14.50%	14.75%	21.08%	21.37%
Ratio of form. to inf. prices	2.899	2.90	2.899	2.90
Quality elasticity	0.51	0.539	0.497	0.539

The income distribution of manufacturing workers is endogenously determined. How-

ever, the income distribution of the 93% of the population not involved in manufacturing can be freely altered. To clearly illustrate the impact of the demand framework, I perform a counterfactual where I conceive of a hypothetical growth process that resulted in equally distributed income gains across this group. Without taking a stand on what caused the increase in income inequality outside of manufacturing, I simulate an equivalent 105% growth in average real per-capita income (the same growth that India went through from 2000 to 2010), but distribute it evenly among all the deciles. In other words, the model otherwise calibrated to the 2010 data, is changed to incorporate the income distribution seen in 2000.

As seen in Figure 1.19, equally distributed income growth produces a decline in informal expenditure share for every decile except the lowest and the highest. In the lowest income decile, consumers are still working their way to fulfilling their basic consumption needs ($\bar{C}$), and so they do not shift to buying any formal goods. The same is true for a large part of the population in the second decile, which is why the fall in its informal expenditure share is lower than D3. Lower reductions from D4 to D9 reflect the declining income elasticity of expenditure share with higher income. The highest income decile is the only decile which is losing income relative in this exercise. In the actual growth process that occurred, it had gained far more than any other decile, and now some of that gain is being redistributed in this counterfactual. D10 shows an increase in informal expenditure share, but a very slight one. This is because the income elasticity of expenditure share for this decile as a whole is very low. In fact, for most of the population in this decile, it is zero. Effectively, this implies that income is being transferred from consumers with zero income elasticity of informal expenditure share to those with negative elasticity. In aggregate, there is a 2.2% fall in the economy wide share of informal expenditure, and a 4.9% fall in informal employment.

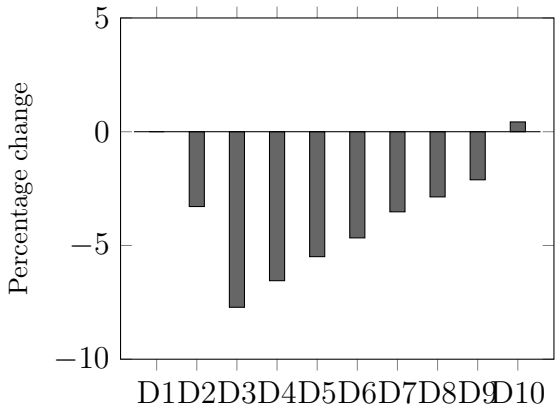


Figure 1.19: Change in informal expenditure shares by decile. Counterfactual with year 2010 per capita income and year 2000 income distribution, compared against 2010 outcome.

As previously mentioned, India experienced a substantial overall improvement in the distribution of educational attainments in the population. Mirroring that, the distribution among the manufacturing workforce also evolved. As we see in the first two columns of Table 1.3, the manufacturing workforce in 2010-11 is significantly better educated than it was in 1999-00. If it were not the case that every educational group's probability of being formally employed reduced except for those with tertiary education, the share of formal employment should have grown more.

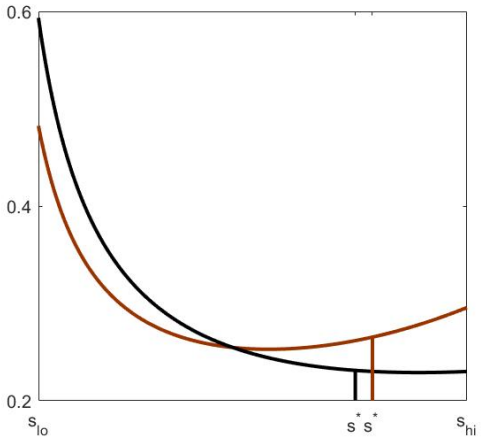


Figure 1.20: Change in the distribution of skill of manufacturing workers between 1999-00 and 2010-11

In the model, this is seen in the difference of the skill distributions between the 1999-00 and 2010-11 (Figure 1.20) calibrations. While there is a higher density of high skill workers, the cutoff level of skill for formal employment s^* has also increased, offsetting the anticipated impact of the improved skill composition in raising formal manufacturing employment. What has caused this increase in skill-selectiveness as the model sees it? Table 1.12, summarizes the changes in key endogenous variables relative to 1999-00. The domestic supply of capital, the productivity of capital relative to labor, and the imports of capital goods are all higher. All three of these lead to capital displacing labor from less complex tasks on the capital-labor threshold. There is also a small increase in z^F. This would be interpreted as the average formal good becoming slightly more demanding to produce, requiring the completion of more tasks in order for a unit to be produced. This too leads to the labor employed in formal firms being required to perform more complex tasks. As these effects pile on each other, formal firms take to increasing their skill selectivity to compensate for the fact that labor is now only being used in more demanding tasks.

Leaving the income distribution unaltered, I perform a counterfactual to see how much the upgrading of the skill distribution would have decreased informal employment if the changes in Table 1.12 had not occurred. I hold down all the variables noted in the table to their 1999-00 values, and all the other parameters to remain at their 2010 calibration. In this scenario, the increase in skill composition causes a decline in manufacturing informality by 2.74%, from 76.99% to 74.25%.

Table 1.12: Equilibrium model outcome relative to 1999-00

	Value
$\frac{\bar{K}_{2010}}{\bar{K}_{2000}}$	1.658
$\frac{\left(\frac{A_k}{A_w}\right)_{2010}}{\left(\frac{A_k}{A_w}\right)_{2000}}$	1.276
$\frac{\bar{K}^{import}_{2010}}{\bar{K}^{import}_{2000}}$	4.318
$\frac{z^F_{2010}}{z^F_{2000}}$	1.030

It cannot be said, that the counterfactual outcome is more desirable on the whole.

Holding down positive shocks that affected the supply, imports and productivity of capital reduces the overall production of the formal good in the economy. This is reflected in the fall in overall average utility. However, without these shocks, the capital intensity does not double, and the change in skill composition does have a notable effect in reducing informality. Therefore upgrading the educational composition of the workforce is a viable policy initiative to examine in the context of informality and its welfare effects. One that is not often discussed in the literature. This paper highlights the crucial fact, that it will only have a negative effect on the overall prevalence of informality, if the skill selectivity of formal firms remains stable. If other shocks are pushing formal firms towards greater skill selectivity, the change in educational composition will have to be even more substantial to achieve reductions in informality.

Table 1.13: Benchmark vs Counterfactual Moments: Skill composition change without capital-aiding shocks

	Benchmark	Counterfactual
Fraction of informal employment	76.99%	74.25%
Ratio of avg formal to informal wages	3.59	3.74
Fraction of formal firms	1.27%	1.39%
Adjusted labor share	68.82%	71.05%
Capital intensity	0.913	0.505
Ratio of formal to informal prices	2.90	3.28
Avg utility relative to benchmark	1	0.843

Finally, I look at what the outcome combining both of the changes would do. The endogenously imposed income is set to remain at the 2000 level, while rising to 2010 levels of real income. The parameters in Table 1.12 are held down to their values in 2000 while the skill composition is allowed to evolve to its 2010 state. If India had seen growth that was equally distributed across all deciles, and had experienced no shocks that reduced the cost of capital or improved its productivity, informality in manufacturing should have declined by 8.6%. Two major mechanisms that are seen to aid the reduction of informality with economic growth in other countries are also

present in India. They have only been sidestepped by a combination of changes that blunted their impact.

1.7 Conclusion

This paper studies how a widespread pattern of declining informality with income, can be reconciled with evidence from the largest country that married a high income growth with no such decline. In doing so, it highlights the importance of two important sources of heterogeneity, supported by microdata from India, which aren't typically discussed in the informality literature. The first is non-homotheticity in consumption, coupled with heterogeneity in how consumers at different income levels respond to income gains (varying informal expenditure share elasticity). This creates a channel for the distribution of income gains to modulate the overall Engel effect on informality. The second is worker heterogeneity along the dimension of skill. This differentiates those who are employed in formal firms from those who aren't, and plays a significant role in deciding distributional outcomes through interactions with capital.

The counterfactuals indicate that with these mechanisms in place, trade liberalisation and improvements in the supply or productivity of capital yield aggregate output growth with no substantial growth in the share of formal employment, and a sustained increased in income inequality. Increasing educational attainment on the other hand, has an amplified impact in reducing informality. The compositional effect, and the increased competitiveness of labor vis-a-vis capital are added to by a substantial indirect effect. The real income gains from such a shock are much more favorable to low income workers who have a negative income elasticity of informal expenditure share. This demand-side effect can potentially strengthen further as the process of formalisation reduces overall inequality. In contrast, attempting to ease the asymmetry in taxation by taxing informal firms, or reducing taxes on their formal counterparts may not produce the same result. Adding product dualism, and worker heterogeneity with formal sector skill selectivity implies that to successfully reduce informality in a welfare improving manner requires providing workers with the skill to work in formal industry, and/or the income to reduce their reliance on informal goods. This is an exciting avenue for future research on the welfare effects of shocks

in a dual economy.

Further illustrating the importance of the demand mechanism, I estimate the change in informal manufacturing employment that would have happened with equally distributed income growth among the wider workforce in non-manufacturing sectors to be 4.9%. The model shows that improved capital productivity, cheaper capital imports, and increased domestic supply of capital goods, combine to displace lower skill labor from already skill-selective formal firms. In their absence, I estimate that the observed improvements in educational composition would have successfully lowered informality by 2.7% on its own, and by a total of 8.6% in conjunction with equally distributed income growth. This implies that the gains in educational attainment in India were not ineffective at reducing informality, but merely inadequate.

Chapter 2

Export Dynamics, Endogenous Bankruptcy and Financial Constraints

2.1 Introduction

The Melitz (2003) model, has become an integral part of the trade literature for its adaptability and ability to explain the misallocation that results from trade barriers. However, trade barriers imposed by governments in the form of conventional tariffs and quotas are not the only factor which affect the entry of firms into exporting. Exporting is an inherently uncertain venture, because demand in the new market cannot be precisely forecast prior to entry. Eaton et al. (2007) use evidence from Colombia to show that a large fraction of new exporting firms do not continue to export beyond their first year. Only a small fraction of firms in each entering cohort rapidly expand in the new market and drive an increase in export volumes.

Firm based models of trade typically involve a fixed cost of exporting. The financial constraints and exporting literature in particular, uses the need to finance this entry cost upfront as the mechanism which explains an export collapse when access to liquidity becomes restricted (Manova (2013), Chaney (2016)). Amiti and Weinstien (2011) back this up by showing that firms tend to depend disproportionately on external financing for exports as compared to domestic operations. If a sunk cost is

to be paid to begin exporting, and in particular if external financing is used as means of overcoming that cost, it stands to reason that a failed export venture can leave the firm financially worse off. Mora (2015) uses data from Colombia to show that export failure is not benign. Unsuccessful exporters are financially more constrained post their failed export venture, and these firms face lower domestic sales and revenue growth as well as an increased chance of bankruptcy.

Firms can therefore choose to delay or forego exporting owing to binding financial constraints, or even for precautionary reasons when these constraints aren't immediately binding. The static models used in Manova (2012), Chaney (2016), Muuls(2008), and most other papers in the financial constraints literature cannot account for precautionary motives. This paper presents a model of export entry and exit in a dynamic setting, with full information credit markets and endogenous bankruptcy. The primary question I attempt to answer is this; what is the impact of endogenous bankruptcy on the extensive margin of firm entry into exporting?

The model presented in this paper is built atop the Melitz (2003) framework. Firms are heterogeneous in their productivity and operate in a monopolistic competition setting. They face idiosyncratic uncertainties in demand and are required to pay some costs of operation upfront. While firms are allowed to accumulate internal resources, they will resort to borrowing if those resources cannot meet the upfront obligations of operating for that period. Creditors offer one period debt and are fully informed about the firm's finances and the uncertainties facing it. This allows them to accurately assess the probability of any firm defaulting on its obligations, which in turn determines the effective interest rate at which that firm can borrow. Default causes firms to go bankrupt and cease to operate, which creates a precautionary motive to avoid an excess of debt. Even a firm whose expected profit upon export entry more than covers the entry costs, may delay such an entry until its own internal resources cover a greater fraction of the entry costs. The paper which comes closest to this one is Caggese and Cunat (2013) which also presents a dynamic model of exporting with costly bankruptcy. However, it does not include credit markets or any other form of external financing/borrowing.

The base model is calibrated to panel data from Colombia, which I assemble by merging customs data with financial data from the Colombian regulator of private limited corporations. This is then compared with outcomes to an identically cali-

brated model without endogenous bankruptcy. All other features remain the same, except that firms can freely roll over debt, and do not default owing to an inability to repay the entire borrowing in the next period before they are able to access the financial market again. The primary result, is that while the incorporation of endogenous bankruptcy only modestly impacts the fraction of firms which attempt exporting in their lifetime, it more seriously impacts the fraction of firms which are exporters in any given year. This is because with endogenous bankruptcy in place, firms wait longer to accumulate more internal resources before they enter exporting (to reduce the need to borrow). They also exit sooner on average, because they are less able to ride out adverse shocks. At the base calibration the fraction of exporting firms in any given year is on average 6% lower with endogenous bankruptcy. A secondary result is that this disparity increases with trade liberalisation.

2.2 Data and Facts

2.2.1 Data

Data on exports is compiled by the Colombian customs authority (DIAN) which logs each export and import transaction. This transaction level data can be aggregated to an annual level for each firm using a time invariant firm identifier which is the firm's Tax Id. This aggregation eliminates any seasonal fluctuations, and allows me to merge trade data with financial data which is reported on an annual basis. Financial data is provided by the Colombian Superintendency of Corporations ("Superintendencia de Sociedades") which is the regulator for all private limited corporations in Colombia. This data includes balance sheets, profit and loss statements as well as cash flow statements that are self reported. Firm's are identified by the same identifier in both datasets, enabling an easy merge. All the firms in either dataset are formal firms.

I restrict myself to manufacturing firms (ISIC section D or C depending on the year/revision), but even there it is worth cautioning that I am not dealing with the entire universe of formal sector manufacturing firms. The Superintendency has a lower threshold of firm size below which it does not mandate reporting. That threshold was set in 2006 by Decree 4350 and amounts to a minimum of $ 5.2 million in annual sales or total assets (more details can be found in Molina and Rao (2014)). Firms which

are smaller than that threshold are still allowed to voluntarily report, but cannot be counted upon to do so. I have also manually removed from the dataset a small number of multinational behemoths that operate in Colombia (think General Motors Colombia, Proctor and Gamble Colombia and so on). The reason for this is that these firms are funded by their parent entity, and their decisions (export, expansion or otherwise) are directed from their global headquarters.

The above description can largely be summed up by stating that the merged panel data I use excludes many small firms, all informal firms and Colombian subsidiaries of very large multinationals. To illustrate the point further, the table below contains a simple comparison of firms seen in the the year 2010 in my dataset and the DANE annual survey of manufacturing for Colombia, which has a lower threshold for data collection than the Superintendencia (at least one plant with 10 employees or $ 100,000 in sales (Eslava and Haltiwanger (2017))).

Table 2.1: Comparison of firm size distribution between the data used and DANE (total sales in USD (2010))

	Dataset Used	DANE
p25	$ 766,147	$ 337,674
p50	$ 2,070,483	$ 879,839
p75	$ 6,107,497	$ 3,273,208
N	4,341	9,945

The total number of unique firms in the dataset that I use is $\sim$ 6800 between 2008 and 2015, about half of which attempt exporting.

2.2.2 Analysis

In this subsection, I use the data to ask three questions.

1. What happens to the financial performance of firms entering exporting?
2. What happens to the financial performance of firms exiting exporting?
3. What is the exit rate of manufacturing firms conditional on years of exporting?

Part 1

Here I use a panel diff-in-diff regression to determine what happens to a firm's finances upon entry into exporting. The "treated" group are all those firms which began exporting within our 8 year window. I only include those firms which have at least one recorded year of purely domestic operations before beginning an export stint. Therefore firms which are already exporters in the first year of the panel are excluded from this regression. The control group are firms that never attempt to export in the observed window. The regression equation used is as follows

$$Y_{it} = \beta^{entry} D_{it} + \gamma_t + \alpha_i + e_{it}$$

D_{it} is an indicator that is 1 if the firm i is an exporter (treated) and the year t is a year on or after the firm has started exporting. β^{entry} is therefore the diff-in-diff coefficient which indicates the impact of entry into exporting on the dependant variable. A firm fixed effect absorbs everything that is firm specific but time invariant, and a year fixed effect absorbs everything that is year specific but firm invariant. The fixed effects panel regression framework minimises omitted variable bias.

Table 2.2: Diff in Diff: Entry of firms into exporting (log values)

Dep Var (logs)	β^{entry}
Total Revenue	0.186***
Domestic Revenue	0.125***
Gross Profits	0.155***
Expenses on Sale/Admin	0.164***
Operating Profits	0.107**
Total Liabilities	0.143***
Current Liabilities	0.160***
Firm FE	Yes
Year FE	Yes
N	22,216

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

Standard errors are clustered by firm id

The results indicate that entry into exporting is accompanied by a substantial increase in total revenues. However, most of this is not due to the added export revenue. As the second row indicates, firms decide to enter exporting at a time when they are also doing well domestically and there is all round growth in sales. As expected, gross profits expand in conjunction with revenues. However, in order to sustain growing sales, the firm also undertakes greater operating expenses. Entry into exporting is accompanied by an expansion of the firm's balance sheet, specifically by the addition of more debt (mostly short term, since the increase in current liabilities accounts for three quarters of the increase in total liabilities).

Part 2

Here I attempt to look at the counterpart to Part 1, which is to see what happens to a firm's financial performance at the time when it is exiting exporting. This underscores the importance of a firm's interaction with financial markets while it makes both entry and exit decisions [1].

For the purposes of this regression below, I will take as the treated group, exiting exporters who have at-least one recorded year of purely domestic operation following their exit from exporting. The control group consists of continuing exporters who don't exit exporting within the window of observation. The regression equations is given below and D_{it} is an indicator that is 1 if a firm i is an exporters that stops exporting and t is a year after the firm has stopped exporting.

$$Y_{it} = \beta^{exit} D_{it} + \gamma_t + \alpha_i + e_{it}$$

[1] At all times, I will use the terms entry and exit to mean entry and exit from exporting. If I wish to refer to firms beginning and ceasing operations in totality, I will refer to it as birth and death/shutdown respectively

Table 2.3: Diff in Diff: Exit of firms from exporting (log values)

Dep Var (logs)	β^{exit}
Total Revenue	-0.308***
Domestic Revenue	-0.241***
Gross Profits	-0.236***
Expenses on Sale/Admin	-0.246***
Operating Profits	-0.138***
Total Liabilities	-0.170***
Current Liabilities	-0.168***
Firm FE	Yes
Year FE	Yes
N	14,141

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

Standard errors are clustered by firm id

An exit from exporting is accompanied by a drop in overall revenues. In addition to lost export revenue, a large part of this is accounted for by the fact that firms seem to exit from exporting at a time when they're witnessing a general decline in revenue (losing sales at home as well). In this paper, I don't examine if there is a causal linkage between exiting exporting and a decline in domestic performance, but Mora (2015) attests that there is. Firms attempt to cushion the fall in gross profits by cutting back on operating expenses, so operating profits see a gentler decline. Exiting firms also reduce their use of short term debt as they scale back operations.

Part 3

In this subsection, I do a very simple analysis of exit rates from exporting conditional on how long firms have been exporting. Exiting from exporting is most common amongst the cohort of firms which have just entered exporting (.i.e are in their first year of exporting). This is in keeping what other papers such as Besedes and Prusa (2006) and Eaton at al. (2007) have reported.

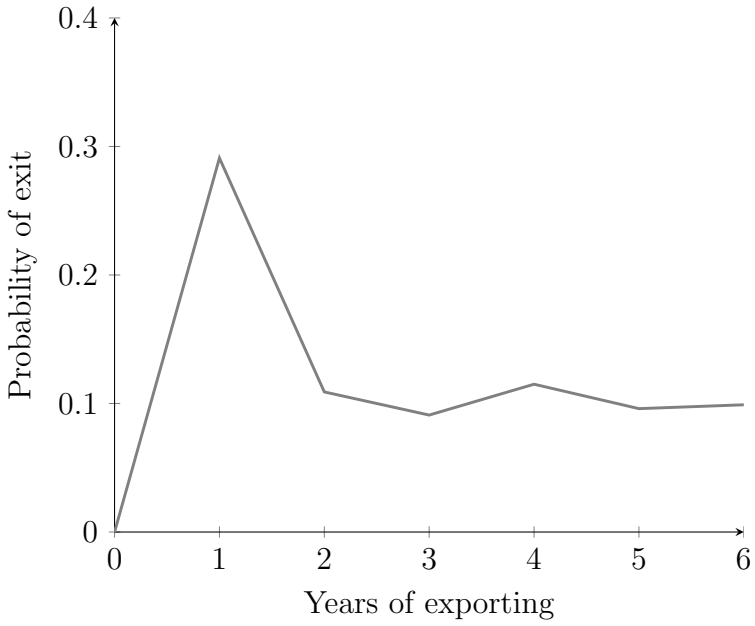


Figure 2.1: Exit rates from exporting conditional on years of exporting

Note that the numbers I find are lower than those reported in Eaton at al (2007). Although they too use Colombian export data, they aren't constrained by a need for financial information from the Superintendency. Their dataset therefore includes smaller firms that this dataset drops.

2.3 Model

2.3.1 Consumer Demand

There is a continuum of firms producing unique varieties $\omega \in \Omega$ in a monopolistic competition framework, and consumer preferences in any period t are given by the following CES function.

$$Q = \left(\int_{\omega \in \Omega} a_t(\omega) q_t(\omega)^{\frac{\sigma-1}{\sigma}} dw \right)^{\frac{\sigma}{\sigma-1}} \tag{2.1}$$

where $a_t(\omega)$ serves as a preference parameter that evolves according to the following random walk process

$$a_t(\omega) = (1-\rho)\bar{a} + \rho a_{t-1}(\omega) + \epsilon^a \tag{2.2}$$

This is a mean reverting random walk. $\rho \in (0,1)$ and ϵ^a is an i.i.d draw from $N(0,\sigma_a^2)$[2]. I normalize both wages and the population size to 1 for simplicity. Therefore the total expenditure in the economy is 1, and the demand for any variety ω in period t is given by

$$q_t(\omega) = \frac{a_t(\omega)^\sigma p_t(\omega)^{-\sigma}}{P^{1-\sigma}} \tag{2.3}$$

2.3.2 Domestic Operations

At think point, I will drop explicitly using ω with the understanding that each equation that refers to a firm is indexed by the variety that said firm produces. Profit for a firm that operates only in the domestic market is given by

$$\pi = \left(p_t - \frac{1}{z}\right) q_t \tag{2.4}$$

Note that I waive the normally found fixed cost of domestic operations for firms. This model will be a partial equilibrium model where the measure of firms/cutoff levels of productivity is exogenously specified. As usual, productivity z is a firm specific draw from a Pareto distribution that doesn't change over the lifetime of the firm, and therefore does not require a time index. The firm is not aware of the current value of a_t when it chooses how much to produce. It is however aware of a_{t-1} based on revenues from the last period, and so it maximises the expected profit function subject to the inverse demand function.

$$max_{q_t} E_{a_t|a_{t-1}} p_t(a_t, q_t) q_t - \frac{q_t}{z}$$
$$p_t(a_t, q_t) = a_t q_t^{\frac{-1}{\sigma}} P^{\frac{\sigma-1}{\sigma}}$$

Plugging the constraint into the objective, this becomes

$$max_{q_t} E a_t P^{\frac{\sigma-1}{\sigma}} q_t^{\frac{\sigma-1}{\sigma}} - \frac{q_t}{z}$$

[2]The choice of a normal distribution is made because I require a distribution which is additive. This implies a possibility that a_t could be negative. Given the unconditional distribution of a_t that results from the eventual calibration, a negative value of a_t is 8 standard deviations below the mean. I don't incorporate negative values in the grid for a_t that I use while numerically solving the model.

Given that $Ea_t = (1-\rho)\bar{a} + \rho a_{t-1}$, I can solve for the optimum quantity to be produced in period t in advance of a_t being known as

$$q_t = \left(\frac{\sigma-1}{\sigma}\right)^{\sigma} ((1-\rho)\bar{a} + \rho a_{t-1})^{\sigma} P^{\sigma-1} z^{\sigma} \tag{2.5}$$

Substituting in the inverse demand function, the price in period t charged by a firm is essentially the price that allows it to sell what it produced at the realised level of demand. A firm is not allowed to hold on to inventory and carry it over to the next period. If the demand matches the expected value that was forecast at the time that the production quantity was decided, then the price is the normal Dixit-Stiglitz markup over the marginal cost.

$$p_t(a_t, a_{t-1}, z) = \frac{\sigma}{\sigma-1}\left(\frac{a_t}{(1-\rho)\bar{a} + \rho a_{t-1}}\right)\frac{1}{z} \tag{2.6}$$

This is why in expectation, $Ep_t = \frac{\sigma}{\sigma-1}\frac{1}{z}$. However, the presence of the preference shock causes it to wobble around this value. It is even possible that the actual realisation of a_t may be so much less than the expected value Ea_t that $\frac{a_t}{Ea_t} < \frac{\sigma-1}{\sigma}$. This would imply that the price at which the product gets sold is less than the marginal cost of producing it, because the firm has badly overestimated demand, overproduced its product and glutted the market. Plugging (2.5) and (2.6) back into the profit function, the maximised domestic profit for a firm in period t is given by

$$\pi_t^D(a_t, a_{t-1}, z) = \left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{a_t}{Ea_t} - 1\right)(Ea_t)^{\sigma} P^{\sigma-1} z^{\sigma-1} \tag{2.7}$$

The only source of uncertainty here is the single a_t. Therefore, the conditional distribution of π_t^D given information available at $t-1$, is a normal distribution with a mean that is given by

$$E\pi_t^D(a_{t-1}, z) = \frac{(\sigma-1)^{\sigma-1}}{\sigma^{\sigma}}(Ea_t)^{\sigma} P^{\sigma-1} z^{\sigma-1}$$

and a variance that is given by

$$\sigma^2_{\pi^D} = \left(\frac{(\sigma-1)^{\sigma-1}}{\sigma^{\sigma}}[Ea_t P z]^{\sigma-1}\right)^2 \sigma_a^2$$

2.3.3 Export Operations

I assume there is a symmetric second country to which firms can export. Exporting involves a one time cost of S^X in the year that firm begin to export after being a purely domestic firm in the previous period, as well as an iceberg cost τ. These costs are common across all firms. While I assume that the same demand shock a_t carries over the firm's export sales, I also add an additional source of profit uncertainty for how well a new product is perceived in the foreign country. This is given by the additive parameter A, which the firm draws from distribution $N(0, \sigma_A^2)$ when it first begins to export, and from thereon remains constant through the export tenure of the firm. This helps match the data which indicates that exit from exporting is most common in the first year. A firm has to start exporting to know how it's product is going to be received in the export market, and once it does, it makes a to stay or exit. This will be expounded on in more length in later sections.

Export profits for a firm in period t are given by

$$\pi_t^X(a_t, a_{t-1}, z, A) = \left(\frac{\sigma-1}{\sigma}\right)^{\sigma} \left(\frac{\sigma}{\sigma-1}\frac{a_t}{Ea_t} - 1\right) (Ea_t)^{\sigma} P^{\sigma-1} \left(\frac{z}{\tau}\right)^{\sigma-1} + A \qquad (2.8)$$

If the firm is contemplating but has not starting exporting yet, there are two sources of uncertainty, a_t and A which the firm has to consider. Both are normally distributed and independent of one another, and therefore the conditional distribution of π_t^X given information from $t-1$, is also normal with a mean of

$$E\pi_t^X(a_{t-1}, z) = \frac{(\sigma-1)^{\sigma-1}}{\sigma^{\sigma}} (Ea_t)^{\sigma} P^{\sigma-1} \left(\frac{z}{\tau}\right)^{\sigma-1}$$

and a variance of

$$\sigma^2_{\pi^X} = \frac{\sigma^2_{\pi^D}}{(\tau^{\sigma-1})^2} + \sigma_A^2$$

If the firm is already an exporter, then A is known and a_t is once again the only source of uncertainty. Once again, the conditional distribution of $\pi_{t,s}^X$ given information from $t-1$, is normal with a mean of

$$E\pi_t^X(a_{t-1}, z, A) = \frac{(\sigma-1)^{\sigma-1}}{\sigma^{\sigma}} (Ea_t)^{\sigma} P^{\sigma-1} \left(\frac{z}{\tau}\right)^{\sigma-1} + A$$

and a variance of

$$\sigma^2_{\pi^X} = \frac{\sigma^2_{\pi^D}}{(\tau^{\sigma-1})^2}$$

2.3.4 Period Sequence

At this point, it would be useful to chronicle the sequence of events and decisions that a firm faces over the course of a period. Each of them will be elaborated on in this subsection.

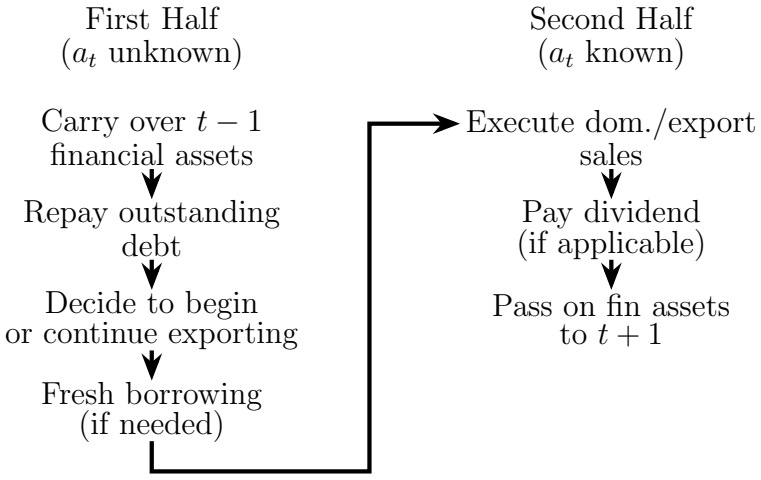


Figure 2.2: Sequence of events and decisions over a period for a firm

Financial Assets

m_t represents the total financial resources that a firm has available at the outset of period t, which comes from assets carried over from period $t-1$. This is given by

$$m_t = min\left[m_{max}, R\left[m_{t-1} + b_{t-1} - D_{t-1} + \pi^D_{t-1} + X_{t-1}\pi^X_{t-1} - I^X_{t-1}S^X\right]\right] \qquad (2.9)$$

In the time index convention used here, all flows are tagged by the period in which they were either earned or paid. Taking each term in turn, m_{max} is the maximum amount of financial assets that a firm will save. Amounts over this will be released as dividend. b_{t-1} is the amount of one period debt borrowed from the financial market in period $t-1$ with a contract that specifies the repayment amount in period t (the next

period) to be D_t. Correspondingly D_{t-1} is the repayment in $t-1$ for any borrowings in period $t-2$. X_{t-1} is an indicator that takes a value of 1 if the firm was an exporter in period $t-1$ and is zero otherwise. I^X_{t-1} is a decision variable that takes a value of 1 if $t-1$ was the period in which the firm decided to become an exporter. Entering an export market carries a one time fixed cost of S^X in addition to the annual fixed cost F_X that is incorporated in $\pi^X_{t-1,s-1}$. R is the discount rate as well as the risk-less rate of return.

Borrowing and Repayment Contracts

A firm only borrows for two reasons. The first is that a firm which has decided to export and needs to cover the cost S^X which has to be paid upfront, before exporting. It would only do this if there are insufficient internal financial assets, because there is no benefit to borrowing if the upfront payments can be met without it. On the contrary, borrowing introduces a risk of endogenous bankruptcy. The second reason is if such bad negative shocks have hit a firm that it's asset balance at the start of a period m_t is negative. Therefore, the firm would like to borrow the following amount in period t

$$b_t(I^X_t) = max[D_t + I^X_t S^X - m_t, 0] \tag{2.10}$$

Every non-zero borrowing in period t, comes with the obligation to repay an amount D_{t+1} in period $t+1$. I assume here that the financial market has full information regarding firm's performance and sales from period $t-1$ while negotiating a contract at the beginning of period t. The firm is also required to disclose its intention to begin or continue exporting. In that context, the parameter λ which represents that probability with which the firm will be able to repay its loan in the next period.

$$\lambda = Pr(m_{t+1} \geq D_{t+1}) \tag{2.11}$$

Because all the uncertainties involved are normal, this is fairly easy to assess. m_{t+1} is a sum of normally distributed factors and is therefore normally distributed itself.

D_{t+1} has to satisfy the incentive compatibility constraints.

$$Rb_t \leq \lambda D_{t+1} + (1-\lambda) min[Em_{t+1}, Rb_t]$$

The RHS of the first equation represents the lenders expected return from lending. If the firm defaults, it goes bankrupt and the lender confiscates the firm's existing financial assets which are expected to be Em_{t+1}. These assets can't exceed Rb_t, because then the firm is not defaulting. A firm is not allowed to roll over debt. It has to successfully repay all previous period debt before it can continue to operate and seek new debt. This expected amount that a lender can recoup has to be at least as great as the return from not lending at all. This implies that the value of D_{t+1} which the financial market would demand in order to lend b_t is the following

$$D_{t+1}(b_t, \lambda) = \frac{Rb_t - (1-\lambda) min[Em_{t+1}, Rb_t]}{\lambda} \tag{2.12}$$

Since λ is itself a function of D_{t+1}, this equation will have to be iteratively solved to find the appropriate D_{t+1}

$$D_{t+1}(b_t) = \frac{Rb_t - Pr(m_{t+1} < D_{t+1}) min[Em_{t+1}, Rb_t]}{Pr(m_{t+1} \geq D_{t+1})} \tag{2.13}$$

λ is fairly straightforward to assess because all the uncertainties involved are normal and additive. This is detailed out in the Appendix B.1.

Firm Decisions

A firm has only two decisions to make. A firm which is non-exporting in period $t-1$ can choose whether to begin exporting in period t. A firm which was an exporter in period $t-1$, can choose whether or not to continue exporting. The decision to enter and continue respectively are given by I_t^X and C_t^X. X_t, the indicator for whether or not a firm is an exporter in period t is given by

$$X_t = (1 - X_{t-1}) I_t^X + X_{t-1} C_t^X \tag{2.14}$$

The firm makes its decisions based on which choice maximises its value function. The value function of a domestic/non-exporting firm in period t is given by $V_t^D(a_t, m_{t+1}, D_{t+1}, z)$ and value function of an exporting firm is given by $V_t^X(a_t, m_{t+1}, D_{t+1}, A, z)$. Both value functions are assessed in the second half of period t right before the dividend is paid.

The decision to begin exporting in period t is made if the firm is not already an exporter in period $t-1$ and expected value of starting to export, conditional on the currently known value of a_{t-1} is greater than the expected value of remaining a non-exporter. This expected value consists of the expected value of profits to be made in the current period plus the continuing value of firm after that.

$$I_t^X(a_{t-1}, m_t, D_t, z) = 1 \quad if$$

$$X_{t-1} = 0 \tag{2.15}$$

$$\begin{aligned} &E\left[\pi_t^D(a_t, a_{t-1}, z) + \pi_t^X(a_t, a_{t-1}, A, z) - S^X + V_t^X(a_t, m_{t+1}, D_{t+1}, A, z) \mid a_{t-1}\right] \\ &\geq E\left[\pi_t^D(a_t, a_{t-1}, z) + V_t^D(a_t, m_{t+1}, D_{t+1}, z) \mid a_{t-1}\right] \end{aligned} \tag{2.16}$$

Similarly, the decision of an exporter to continue exporting in period t is made if the firm is already an exporter in period $t-1$, and the expected value of continuing to export exceeds that of exiting and becoming a non-exporter.

$$C_t^X(a_{t-1}, m_t, D_t, A, z) = 1 \quad if$$

$$X_{t-1} = 1 \tag{2.17}$$

$$\begin{aligned} &E\left[\pi_t^D(a_t, a_{t-1}, z) + \pi_t^X(a_t, a_{t-1}, A, z) + V^X(a_t, m_{t+1}, D_{t+1}, A, z) \mid a_{t-1}\right] \\ &\geq E\left[\pi_t^D(a_t, a_{t-1}, z) + V^D(a_t, m_{t+1}, D_{t+1}, z) \mid a_{t-1}\right] \end{aligned} \tag{2.18}$$

The value functions now have to be fleshed out. These are basically the net present value of future expected dividends and dissolution payments. Dividends are paid at the end of a year if the firm's financial assets will go over the maximum value of m_{max} at the beginning of the next period. In other words

$$div_t = max[m_{t-1} + b_{t-1} - D_{t-1} + \pi_{t-1}^D + X_{t-1}\pi_{t-1}^X - I_{t-1}^X S^x - \frac{m_{max}}{R}, 0] \tag{2.19}$$

A dissolution payment to investors occurs if the firm is hit with an exogenous death

shock. This is different from endogenous bankruptcy, wherein the firm dies if in period t if $m_t < D_t$. In this case, there is no payment to investors. The creditors seize the firms financial assets. However, a firm can along be hit with an exogenous death shock with probability δ. In this case, the firm is dissolved and its financial assets net of debt revert to its investors. With that context $V^D_{t-1}(a_{t-1}, m_t, D_t, z)$ being evaluated in period $t-1$ right before the dividend payment of that period is given by

$$\begin{aligned} V^D_{t-1}(a_{t-1}, m_t, D_t, z) = div_{t-1} + 1(m_t \geq D_t)\frac{1}{R}\Bigg[\delta E(m_t - D_t) + \\ (1-\delta)E\Big(I^X_t(a_{t-1}, m_t, D_t, z)V^X_t(a_t, m_{t+1}, D_{t+1}, A, z) + \\ (1 - I^X_t(a_{t-1}, m_t, D_t, z))V^D_t(a_t, m_{t+1}, D_{t+1}, z)\Big)\Bigg] \end{aligned} \tag{2.20}$$

$$\begin{aligned} V^X_{t-1}(a_{t-1}, m_t, D_t, z) = div_{t-1} + 1(m_t \geq D_t)\frac{1}{R}\Bigg[\delta E(m_t - D_t) + \\ (1-\delta)E\Big(C^X_t(a_{t-1}, m_t, D_t, A, z)V^X_t(a_t, m_{t+1}, D_{t+1}, A, z) + \\ (1 - C^X_t(a_{t-1}, m_t, D_t, A, z))V^D_t(a_t, m_{t+1}, D_{t+1}, z)\Big)\Bigg] \end{aligned} \tag{2.21}$$

Things are somewhat analogous between the two equations, so I will only explain Equation (2.20). A firm is assumed to continue operations unless it dies by endogenous bankruptcy or the exogenous death shock. A firm that is a non exporter in period $t-1$ can choose whether or not to become an exporter in period t. This choice affects the continuing value of the firm. Equations (2.20) and (2.21) have to be solved simultaneously by VFI.

2.3.5 Firm Birth

Firm birth is highly simplified. At the beginning of time, firms are born and draw their productivity from a Pareto distribution $G(z)$. Firms at their initiation have both zero debt and zero accumulated financial assets. Any firm that dies for any reason is replaced by a firm of the same productivity which also starts with zero debt and zero accumulated financial assets. In effect, the death of a firm is simply a mechanism by

which its balance sheet is wiped clean. Of course, if the dead firm was an exporter, its replacement firm will have to re-enter exporting if it so chooses and at the point of entering exporting, it receives a new draw of A like any firm that enters exporting for the first time.

2.4 Calibration

Table 2.4: Model Moments compared with Data Moments

		1999-00	
Parameter	Target Moment	Data	Model
δ	Overall firm death rate	7.9%	7.9%
ρ	Autocorr. of domestic rev.	0.4	0.41
σ_a	Med. rel std dev. of dom. rev.	0.23	0.22
τ	Exp. to tot sales of exporting firms	0.38	0.38
σ_A	Frac of exp. exiting in year 1	0.29	0.28
S^X	Frac. of exporting firms	0.48	0.49
m_{max}	Mean total assets/dom. rev.	1.92	1.90

These are largely self explanatory target moments. The other parameters involved in the model are either statutory, taken from the literature or independently identified. R is taken to be the average real interest rate in Colombia for the period in question. The value of the CES elasticity of substitution σ is taken from Constantini and Melitz (2009). The Pareto shape parameter for the distribution $G(a)$ is identified using the mean to median ratio of domestic revenues.

2.5 Results

As noted in the introduction, the results will focus on two primary questions. How much of a difference is the introduction of endogenous bankruptcy making to the extensive margin of firm entry under this calibration? How differently does a model with endogenous bankruptcy behave when compared to one without such a feature

in responding to trade liberalisation? Given that the model presented in this paper is partial equilibrium, it is ill-equipped to answer questions of welfare. Therefore I will constrain myself to asking questions related to firm behaviour, particularly export entry and exit.

In that regard, the presence of preference shocks in addition to heterogeneous productivity will imply that there isn't a sharp cutoff level of productivity beyond which firms will export. Larger, more productivity firms (size in Table 2.5) export with greater probability, and beyond a point with near certainty. Lower productivity firms will attempt exporting if they are currently experiencing a very good preference shock (which affects their expectation of future shocks), and have accumulated significant internal resources to reduce or eliminate any borrowing requirement. Higher productivity firms will export despite poor preference shocks, because their productivity makes exporting profitable enough to overcome to the beachead cost even without good preference shocks. This is consistent with the empirical data, which also lacks a sharp size cutoff.

Table 2.5: Model Validation

Moments (not targeted)	Data	Model
% of exporters, firms $<$ 25% of size percentile	25%	0%
% of exporters, firms between 25 and 50 percentile	42%	15%
% of exporters, firms between 50 and 75 percentile	57%	84%
% of exporters, firms between 75 and 100 percentile	70%	100%
% of exporters, 1 year old firms	32%	23%
% of exporters, 2 year old firms	38%	28%
% of exporters, 3 year old firms	40%	34%
% of exporters, 4 year old firms	43%	37%
% of exporters, 5 year old firms	47%	40%
% of exporters, 6 year old firms	48%	43%
% of exporters, 7 year old firms	50%	45%

Also consistent with the data, is the model's prediction that older firms are more

likely to be exporters[3]. In the model, the mechanism that causes this pattern is the accumulation of internal financial assets with age, which reduces the need to borrow to pay down S^X (recall that borrowing carries a chance of bankruptcy). That accumulation of assets can be seen in Figure 2.3.

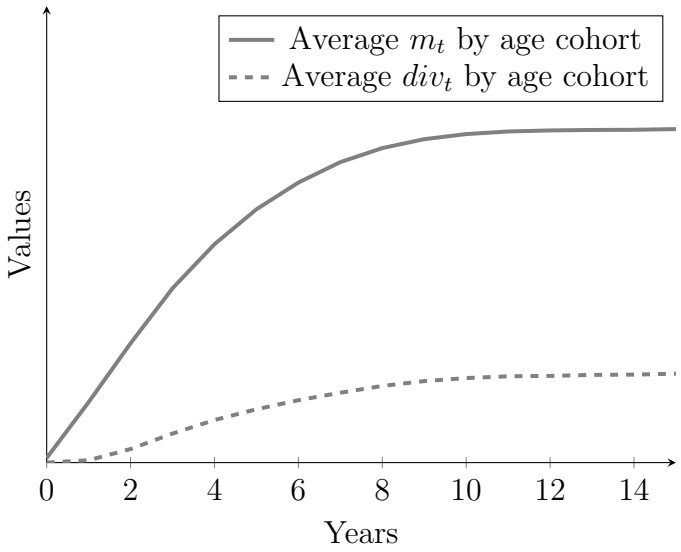


Figure 2.3: Average financial assets and dividend payments by age cohort

Firms are also more likely to enter exporting in the immediate aftermath of a good preference shock owing to the non-zero serial correlation which leads to a higher expectation of the next period's a_t (recall that preference shocks are common across domestic and export markets). This matches the data which indicates that firms generally enter exporting when domestic revenues are also buoyant.

[3]Note that determining age in the empirical data is not an exact affair. The first year in which a firm appears in our panel may simply be the first year in which it was large enough to begin reporting, rather than the year in which the firm was actually founded.

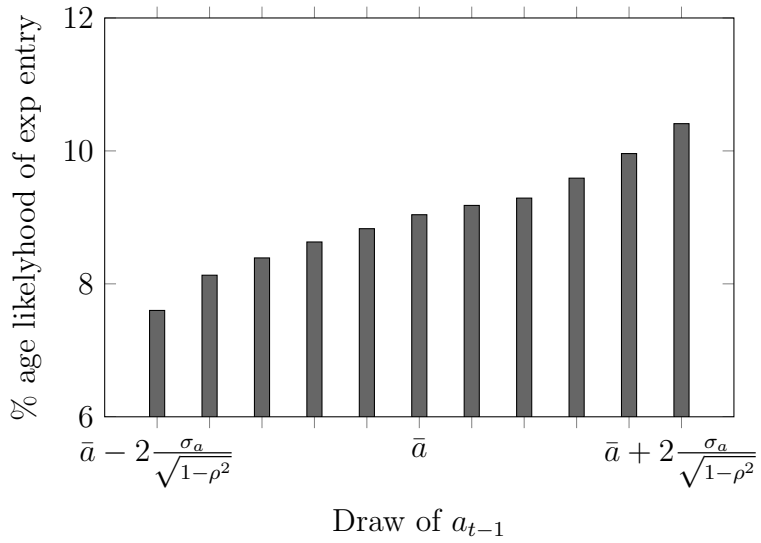


Figure 2.4: Percentage likelyhood of export entry among non-exporting firms based on the previous period's draw of the preference shock

2.5.1 Impact of Endogenous Bankruptcy

Table 2.6: Comparison of moments in model with and without endogenous bankruptcy

	Model	
Target Moment	w Endog. Bank.	w/o Endog. Bank.
Overall firm death rate	7.9%	7.5%
Autocorr. of domestic rev.	0.41	0.41
Med. rel std dev. of dom. rev.	0.22	0.22
Exp. to tot sales of exporting firms	0.38	0.38
Frac of exp. exiting in year 1	0.28	0.21
Frac. of exporting firms	0.49	0.52
Mean total assets/dom. rev.	1.90	1.91

To assess the effect of endogenous bankruptcy, I remove it from the calibrated base model and compare it to the original. In the modified model without endogenous bankruptcy, the only change is that firms are allowed to rollover debt, and are no

longer constrained to repay what they borrowed in the last period before undertaking any fresh borrowing. This implies that they never go bankrupt owing to inability to repay the previously taken debt. Firms still can and do die due to the random death shock δ. For creditors/bank, this means lending is not quite risk free (a random death shock can result in a lapse in full payment), but is significantly lower risk than in the base model which results in lower effective rates being charged.

Table 2.6 looks at the same moments seen in Table 2.4 and compares the model with and without endogenous bankruptcy. Without it, overall firm death rates are slightly lowered, a slightly higher fraction of firms attempt exporting and exit rate in year 1 drops substantially. The inclusion of endogenous bankruptcy only prevents about 3% of firms from ever attempting exporting. Unless they die in the meantime, firms always have the option of accumulating internal financial assets to make the export attempt. However, endogenous bankruptcy reduces the fraction of exporting firms in any one year in a more measurable way owing to two other reasons.

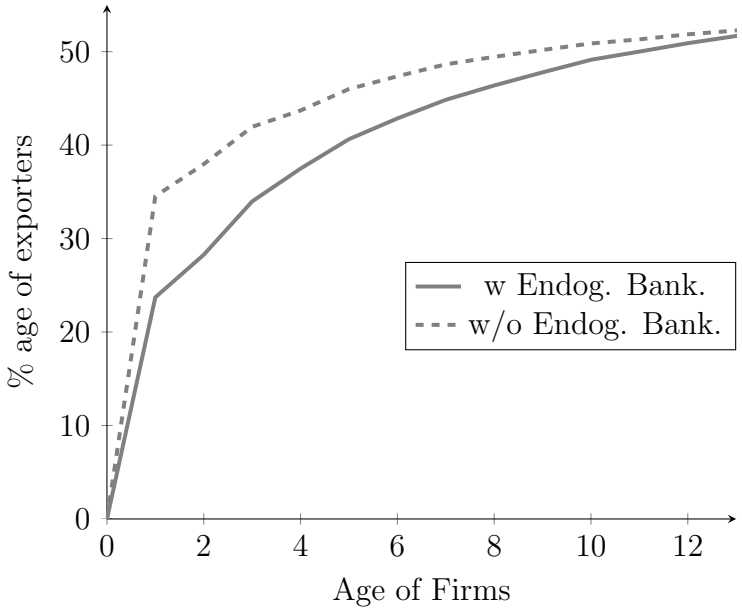


Figure 2.5: Percentage of exporters by age cohort with and without endogenous bankruptcy

The first is that firms on average wait longer before they make their export attempt. With endogenous bankruptcy, many more firms aren't willing to jump in till they can cover more of the upfront fixed cost on their own. The second is that in addition

to waiting longer to enter exporting, firms exit faster when endogenous bank is a feature. In general, the high exit rate in the first year of exporting in the model is driven by firms getting a a poor draw of A, something they don't discover till they begin exporting. At this point, the cost of S^X has already been paid, and firm has to decide if it will continue exporting. If the draw of A is bad but not exceptionally bad, it is still possible for exporting to be profitable in the long term if the preference shocks realized a_t aren't also frequently bad. With the ability to rollover debt, and without the threat of endogenous bankruptcy if the firm fails to repay its debt in any year, a firm more often finds it favorable to just wait for good preference shocks.

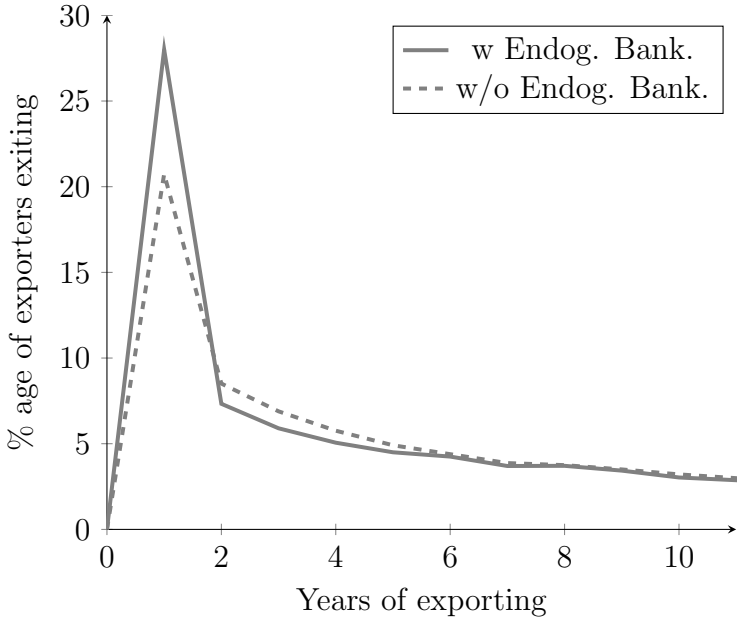


Figure 2.6: Exit rate from exporting conditional on years of exporting

With endogenous bankruptcy, a firm would need good preference shocks to be realised in the very short run to prevent default and death. So a greater fraction of firms that attempt exporting and receive bad draws of A just choose to retreat and exit exporting in the first year. This is seen in Figure 2.6. In the case of the base model (with endogenous bankruptcy), since most of the firms that have highly adverse draws of A drop out in the first year, the exit rate thereafter drops slightly below the values for the model without endogenous bankruptcy. Both models converge to a similar value when it comes to exit rates for long running exporters. The only reason these

firms to typically exit is death due to the random death shock δ.

All in all, though nearly as many firms attempt exporting, firms on average have a shorter tenure in export markets with endogenous bankruptcy. Owing to this, the fraction of firms exporting in any given period with endogenous bankruptcy is 42% and without it is 48%, a more substantial difference of 6%.

Trade Liberalisation

Trade liberalisation exacerbates the difference in outcomes with and without endogenous bankruptcy. The same two models are run again with the iceberg cost τ lowered from 1.17 to 1.1. With and without endogenous bankruptcy, the fraction of firms which attempt exporting are 66% and 70% respectively, a difference of 4%. The fraction of firms which are exporters in any one period are 55% and 63% respectively, a difference of 8%.

2.6 Conclusion

In this paper, I present a dynamic model of exporting in which firms are allowed to accumulate internal resources and borrow externally in order to pay the upfront fixed cost necessary to access an export market. These avenues also allow the firm to survive periods wherein adverse preference shocks lead to losses. External borrowing comes with the risk of endogenous bankruptcy because all borrowing has to be repaid the next period before the firm is allowed to continue operations or access the financial markets again. Financial markets operate with full information in that they are aware of everything about the firm's financial status and prospects that the firm itself is aware of. However, there is uncertainty with respect with future earnings owing random preference shocks that affect revenues in both domestic and export markets, as well as an additional source of profit uncertainty in export markets that only becomes known once exporting begins. Creditors take account of this uncertainty in the debt contract they offer.

Endogenous bankruptcy is a fate that befalls relatively few firms overall. Comparing the base model to the same model without endogenous bankruptcy (where firms are allowed to roll over their debt rather than default and die), shows that

only about and additional 0.4% of firms a year die because of it. Firms for the most part successfully avoid putting themselves in situations where they suffer from it by accumulating internal resources and postponing export entry which involves the aforementioned upfront fixed cost. They also exit export markets faster in the face of an adverse profit shock A, because they can't wait for better preference shocks while they borrow to overcome temporary losses in the export market. A combination of a modestly smaller fraction of firms attempting export entry, and the shorter tenure in export markets results in an extensive margin of exporting that is 6% smaller each year in the base calibration. Secondly, this difference in outcomes between the model with and without endogenous bankruptcy, widens with trade liberalization. A 6% reduction in the iceberg cost of exporting, boosts the difference in the fraction of exporting firms to 8%.

Endogenous bankruptcy is not a frequently studied feature in the trade literature. However, a growing literature exists on financial constraints and trade, and a fixed cost of exporting is practically the norm in modern trade models. Going beyond static models allows a fuller consideration of the effects of borrowing to overcome uncertainties and such fixed costs. The primary contribution of this paper is to show that endogenous bankruptcy can have non trivial effects on the extensive margin of exporting directly and via precautionary effects.

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Appendix A

Informality, Inequality and Trade: Understanding Development without Formalization

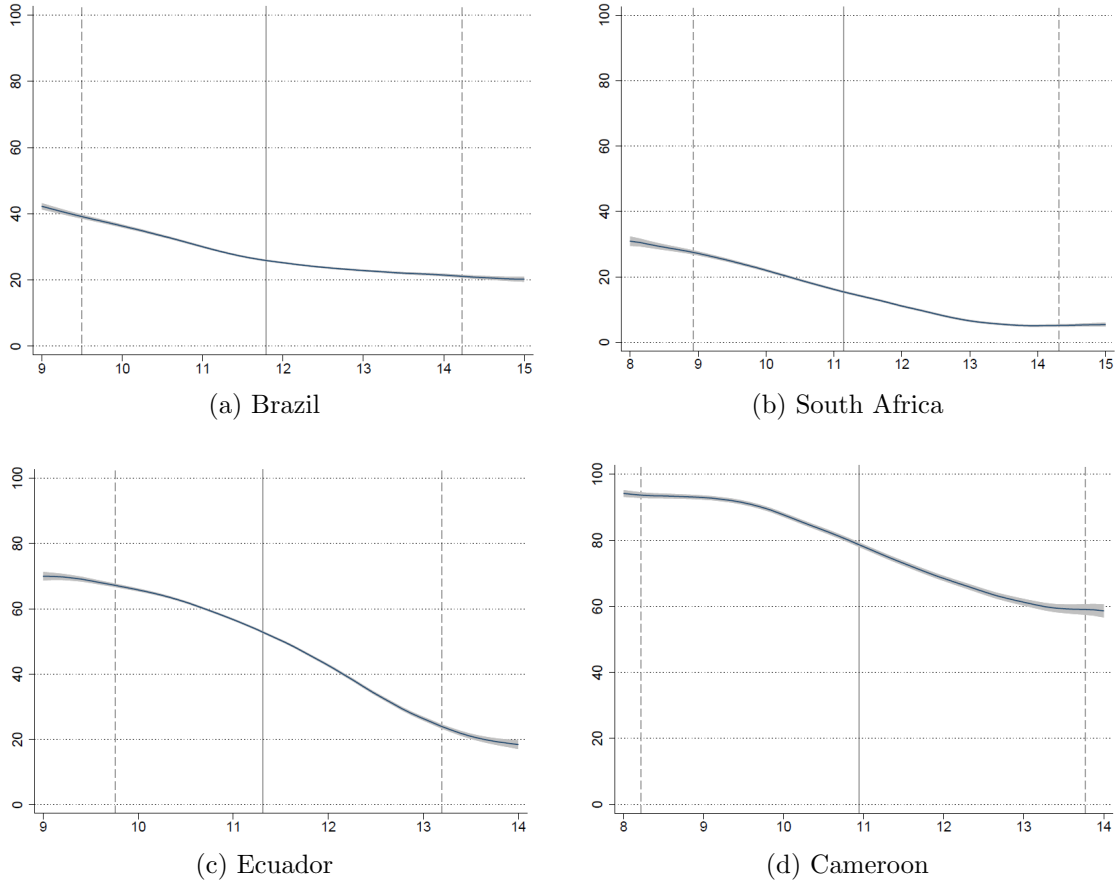
A.1 Additional Data

Table A.1: Capital Intensity Regressions: Plant machinery per employee in Formal and Informal Firms

Dep Var: Log Plant Machinery per Emp				
	(1)	(2)	(3)	(4)
Formal	4.1191***	4.1607***		
Size (no of employees)	0.0003***		0.0003 ***	0.0016 ***
cons	-1.0188	-1.0180	6.5642	-1.0388***
Sample	All	All	Formal Only	Informal Only
N	136,053	136,053	36,392	99,661
R^2	0.3989	0.3987	0.1189	0.3188

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

The data used and the fixed effects included are the same as Table 1.2. Plant machinery in 000' INR divided by the number of employees is the dependant variable.



(a) Brazil (b) South Africa

(c) Ecuador (d) Cameroon

Figure A.1: Figures from Appendix A of Bachas et al. (2009) showing overall informal expenditure share Engel curves for some of the countries which they look at

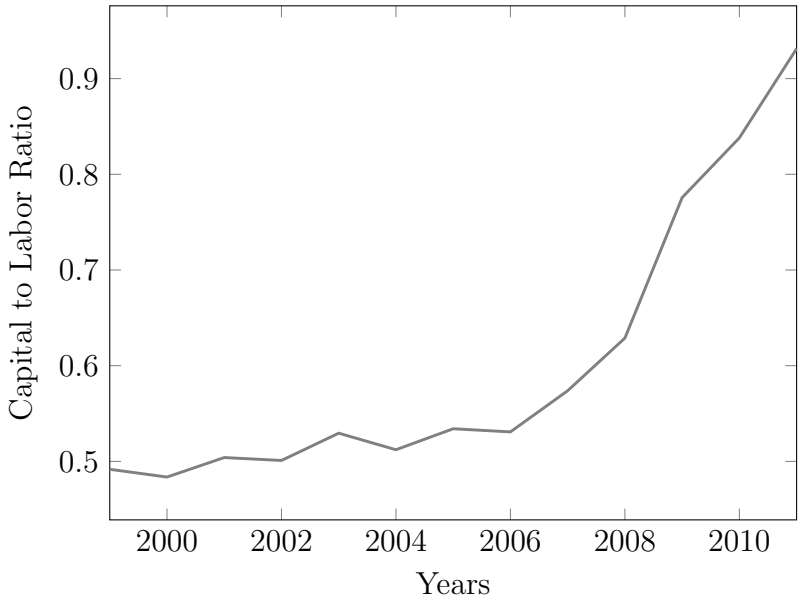


Figure A.2: Capital to Labor Ratio in formal firms (Computed as the ratio of Fixed Capital deflated by WPI for Machinery and Machine tools, to Total Workers Engaged)

Source: Author's calculations from ASI summary data

A.2 Model Appendix

Given that $G(\alpha) = 1 - \alpha^{-\theta}$, and assuming that d is high enough so as to stop any informal firms from using capital, we can simplify some of the equations earlier seen.

A.2.1 Informal Home Firms

The price charged by an informal firm with demand draw α is given by Equation (1.15).

$$p_H^I(\alpha) = \begin{cases} \frac{\sigma^I}{\sigma-1}\frac{w_H^I b^I z^I}{A_w} & if \quad q_H^I(\alpha) \leq \frac{A_w \bar{l}}{b^I z^I} \\ \\ \frac{\sigma^I}{\sigma-1}\frac{b^I z^I}{A_w}\left(w_H^I + \Upsilon'(l(q_H^I) - \bar{l})\right) & if \quad q^I(\alpha) > \frac{A_w \bar{l}}{b^I z^I} \end{cases} \tag{A.1}$$

Where

$$\begin{aligned}\Upsilon'(l(q_H^I)-\bar{l}) &= vm(l(q_H^I)-\bar{l})^{m-1} \\ &= vm(\frac{\alpha E_H^I {P_H^I}^{\sigma^I-1} p_H^I(\alpha)^{-\sigma^I} b^I z^I}{A_w} - \bar{l})^{m-1}\end{aligned}$$

The price in the case of $q_H^I(\alpha) > \frac{A_w\bar{l}}{b^I z^I}$ will have to be iteratively estimated. I define $\hat{\alpha} = \alpha : q_H^I(\alpha) = \frac{A_w\bar{l}}{b^I z^I}$. Knowing that Then $\hat{\alpha}$ is given by

$$q_H^I(\hat{\alpha}) = \alpha E^I {P_H^I}^{\sigma^I-1}\left(p_H^I(\alpha)\right)^{-\sigma^I} = \frac{A_w\bar{l}}{b^I z^I}$$

At the boundary, $p^I(\hat{\alpha}) = \frac{\sigma^I}{\sigma-1}\frac{w^I b^I z^I}{A_w}$. Therefore

$$\hat{\alpha} = \frac{A_w\bar{l}}{b^I z^I E_H^I}\left(\frac{\sigma^I}{\sigma^I-1}\frac{w_H^I b^I z^I}{A_w}\right)^{\sigma^I} {P_H^I}^{1-\sigma^I}$$

The price index, of which a part will have to be estimated numerically is given below

$$P_H^I = \left(M_{EH}\left(\frac{\sigma^I}{\sigma^I-1}\frac{w_H^I b^I z^I}{A_w}\right)^{1-\sigma^I}\frac{\theta(\bar{\alpha}^{1-\theta}-\hat{\alpha}^{1-\theta})}{\theta-1} + M_{EH}\int_{\hat{\alpha}}^{\alpha^*}\alpha p_H^I(\alpha)^{1-\sigma^I} g(\alpha)d\alpha\right)^{\frac{1}{1-\sigma^I}}$$

Profits of informal firms are given by

$$\pi_H^I(\alpha) = \begin{cases}\alpha E_H^I {P_H^I}^{\sigma^I-1}\frac{1}{\sigma^I}\left(\frac{\sigma^I}{\sigma^I-1}\frac{w_H^I z^I}{A_w}\right)^{1-\sigma^I} - S_H^I & if \quad \bar{\alpha} < \alpha < \hat{\alpha} \\ \\ \alpha_H^I E_H^I\left(\frac{p_H^I(\alpha)}{P_H^I}\right)^{1-\sigma^I} - w^I l - S_H^I - v(l-\bar{l})^m & if \quad \hat{\alpha} < \alpha < \alpha^*\end{cases}$$

$$\Pi_H^I = M_{EH}\left(E^I {P_H^I}^{\sigma^I-1}\frac{1}{\sigma^I}\left(\frac{\sigma^I}{\sigma^I-1}\frac{w^I z^I}{A_w}\right)^{1-\sigma^I}\frac{\theta(\bar{\alpha}^{1-\theta}-\hat{\alpha}^{1-\theta})}{\theta-1} + \int_{\hat{\alpha}}^{\alpha^*}\pi_H^I(\alpha)g(\alpha)d\alpha\right)$$

A.2.2 Formal Home Firms

The price index is

$$P_H^F = \left(M_{EH} \left(p_H^F\right)^{1-\sigma^F} \int_{\alpha_H^*}^{\infty} \alpha g(\alpha) d\alpha + M_{ERow} \left(p_{RoWH}\right)^{1-\sigma^F} \int_{\bar{\alpha}_{RoWH}}^{\infty} \alpha g(\alpha) d\alpha \right)^{\frac{1}{1-\sigma^F}}$$
$$= \left(M_{EH} \left(p_H^F\right)^{1-\sigma^F} \frac{\theta {\alpha^*}^{1-\theta}}{\theta - 1} + M_{ERow} \left(p_{RoWH}\right)^{1-\sigma^F} \frac{\theta \bar{\alpha}_{RoWH}^{1-\theta}}{\theta - 1} \right)^{\frac{1}{1-\sigma^F}}$$

If the export threshold is $\bar{\alpha}_{HRoW}$ profits are given by

$$\pi_H^F(\alpha) = \begin{cases} (1-t_c)\left(\alpha \frac{E^F}{\sigma^F(1+t_s)} {p_H^F}^{1-\sigma^F} {P_H^F}^{\sigma^F-1} - S_H^F\right) & if \quad \alpha^* < \alpha < \bar{\alpha}_{HRoW} \\ (1-t_c)\left(\alpha \frac{E^F}{\sigma^F(1+t_s)} {p_{FH}}^{1-\sigma^F} P_{FH}^{\sigma^F-1} + \alpha \frac{E_{RoW}}{\sigma^F(1+t_s)} {p_{FHRoW}}^{1-\sigma^F} P_{RoW}^{\sigma^F-1} \right. & \\ \qquad \left. -S_H^F - S_{HRoW}\right) & if \quad \alpha \geq \bar{\alpha}_{HRoW} \end{cases}$$

$$\Pi_H^F = M_{EH}(1-t_c)\left(\frac{E^F}{\sigma^F(1+t_s)} {p_H^F}^{1-\sigma^F} {P_H^F}^{\sigma^F-1} \frac{\theta {\alpha^*}^{1-\theta}}{\theta-1} + \right.$$
$$\left. \frac{E_{RoW}}{\sigma^F(1+t_s)} {p_{HRoW}^F}^{1-\sigma^F} P_{RoW}^{\sigma^F-1} \frac{\theta \bar{\alpha}_{RoWH}^{1-\theta}}{\theta-1} + S_H^F {\alpha^*}^{-\theta} + S_{HRoW} \bar{\alpha}_{HRoW}^{-\theta} \right)$$

Capital

The cost of capital for formal firms in equilibrium is anchored in relation to $w(s^*) = w_I^H$ by (1.10). Substituting in (1.5) and (1.6), we have

$$c_{kH}^F = \frac{w_H^I(1+t_w)}{A_w\left(1 - \frac{(z^*-z_w)}{s^*}\right)} \frac{A_k}{\left(1 + (z^*-z_k)^{\frac{1}{\nu}}\right)}$$

With r_{RoW} chosen as the numeraire, r_H^F given c_{kH}^F is

$$r_H^F = \left(\frac{{c_k^F}^{1-\sigma_k} - \beta_H^{\sigma_k} \tau^{1-\sigma_k}}{(1-\beta_H)^{\sigma_k}} \right)^{\frac{1}{1-\sigma_k}}$$

Given domestic supply of capital $\bar{K}_H$, the composite capital employed for production

is given by

$$K_H^F = \left(\frac{(1-\beta_H) c_{kH}^F}{r_H^F} \right)^{-\sigma_k} \bar{K}_H$$

Given z^*, in order to use all of K_H^F in formal production and have the capital market clear, N_H^F (the total quantity of formal goods produced in the economy) has to follow the following relationship

$$N_H^F = \frac{K_H^F A_k}{b^F \left(z^* + \frac{(z^* - \bar{z}_k)^{\frac{1}{\nu}+1}}{\frac{1}{\nu}+1} \right)}$$

A.2.3 Row Firms

Trade with home does not affect the RoW price index. This is determines solely by the distribution and mass of firms in RoW, who draw their demand α from the same distribution as home firms. The price index, and the quantity sold by an RoW firm with demand draw α are given by

$$P_{RoW} = p_{RoW} \left(\frac{M_{ERow} \theta \bar{\alpha}_{RoW}^{1-\theta}}{\theta - 1} \right)^{\frac{1}{1-\sigma^F}}$$
$$q_{RoW}(\alpha) = \frac{\alpha E_{RoW}}{p_{RoW}} \frac{\theta - 1}{\theta M_{ERow}} \bar{\alpha}_{RoW}^{\theta-1}$$

The profit earned by a firm with demand draw α, and consequently the total profit across all firms becomes

$$\pi_{RoW}(\alpha) = (1 - t_c) \left(\frac{\alpha E_{RoW}}{\sigma^F (1 + t_s)} \frac{\theta - 1}{\theta M_{ERow}} \bar{\alpha}_{RoW}^{\theta-1} - S_{RoW} \right)$$
$$\Pi_{RoW} = (1 - t_c) \left(\frac{E_{RoW}}{\sigma^F (1 + t_s)} - S_{RoW} M_{ERow} \bar{\alpha}_{RoW}^{-\theta} \right)$$

$\bar{\alpha}_{RoW}$ and M_E are given by

$$\bar{\alpha}_{RoW} = \left(\frac{S_{RoW}(1-t_c)}{S_{ERow}(\theta-1)}\right)^{\frac{1}{\theta}}$$
$$M_{ERow} = \frac{E_{RoW}(1-t_c)}{\sigma^F(1+t_s)\theta S_{ERow}}$$

A.3 Proof Appendix

A.3.1 Proof of Lemma 1

The lemma states that a single crossing can be achieved with low enough values of ν s.t $\widehat{mc}_k^F(z) < \widehat{mc}_w^F(z)$ if $z \in [0, z^*)$, and $\widehat{mc}_k^F(z) \geq \widehat{mc}_w^F(z)$ if $z \in [z^*, z^F]$ given that $\widehat{mc}_k^F(0) < \widehat{mc}_w^F(0)$ and $\bar{z}_k < z_F - 1$.

$\widehat{mc}_k^F(z)$ and its derivatives are given below.

$$\widehat{mc}_k^F(z) = \frac{c_{kH}^F}{A_k}\left(1 + 1(z > \bar{z}_k)(z-\bar{z}_k)^{\frac{1}{\nu}}\right)$$
$$\widehat{mc}_k^F(z)' = 1(z > \bar{z}_k)\frac{c_{kH}^F}{A_k\nu}(z-\bar{z}_k)^{\frac{1}{\nu}-1}$$
$$\widehat{mc}_k^F(z)'' = 1(z > \bar{z}_k)\frac{c_{kH}^F}{A_k\nu}\left(\frac{1}{\nu}-1\right)(z-\bar{z}_k)^{\frac{1}{\nu}-2}$$

$\widehat{mc}_k^F(z)' \geq 0$ and $\widehat{mc}_k^F(z)'' \geq 0$. Beyond $\bar{z}_k$, $\widehat{mc}_k^F(z)$ is a convex, strictly increasing function. Since $\bar{z}_k < z_F - 1$, $\widehat{mc}_k^F(z_F) \to \infty$ as $\nu \to 0$. So as long as $\widehat{mc}_w^F(z_F)$ is finite, it can always be ensured that $\widehat{mc}_k^F(z_F) > \widehat{mc}_w^F(z_F)$ with a low enough value of ν.

This implies that there are an odd number of crossings between $\widehat{mc}_k^F$ and $\widehat{mc}_w^F$. It could be the desired number of crossings, which is 1, or any odd number greater than that. I will show that 3 crossings can be avoided, and the same arguments holds for any odd number of crossings greater than that. Let $0 < z_1 < z_2 < z_3 < z^F$ be the three crossings. Then, the following will have to hold true

$$\widehat{mc}_k^F(z_1)' > \widehat{mc}_w^F(z_1)'$$
$$\widehat{mc}_k^F(z_2)' < \widehat{mc}_w^F(z_2)'$$
$$\widehat{mc}_k^F(z_3)' > \widehat{mc}_w^F(z_3)'$$

If $z_1 < \bar{z}_k$, then $\widehat{mc}_k^F(z_1)' = 0$ and the first condition fails. Therefore $z_3 > z_2 > z_1 > \bar{z}_k$. If $z_1 < \bar{z}_k + 1$, then $\widehat{mc}_k^F(z_1)'$ decreases as ν decreases, and a sufficiently low value of ν can break condition 1. If condition 1 is violated, then z_2 is not a crossing because $\widehat{mc}_k^F(z_2) < \widehat{mc}_w^F(z_2)$. Therefore there will only be one crossing.

If $z_1 > \bar{z}_k + 1$, then it has to be the case that $z_2 > \bar{z}_k + 1$. Then $\widehat{mc}_k^F(z_2)'$ increases as ν decreases, and a sufficiently low value of ν can break condition 2. In this case, either one of z_1 or z_3 have to stop being crossings.

A.3.2 Proof of Lemma 2

This proof is by contradiction. I evaluate the two possible cases that violate this Lemma and show that they cannot happen.

Case 1: $n_w(s, z) > 0$ where $z < z^*$ and $s > s^*$

From Lemma 1 a worker will not be employed in a formal firm to do a task $z < z^*$ because the marginal cost of employing a worker to do that task is more than that of using capital. Therefore, if a worker is employed in a task in this range of this complexity, it is in an informal firm. This case can therefore be restated as $n_w(s, z) > 0$ where $z < z^I$ and $s > s^*$.

From Equation (1.10) and (1.7), it is known that $w(s^*) = w_H^I$. For $s \geq s^*$, Equation (1.9) can be resolved as

$$\frac{dw(s)}{ds} = w(s)\frac{(\phi(s) - \bar{z}_w)}{s(s - (\phi(s) - \bar{z}_w))} \quad if \quad s^* \leq s \leq s_{hi}$$

The range of $\phi(s)$ is $[z^*, z^F]$, and $z^* > \bar{z}_w$ by assumption. The numerator is therefore always positive. From Equation (1.5), it is known that workers with a level of skill $s \leq z - z_w$ are unemployable in the task z because their productivity would be zero. Therefore the assignment function $\phi(s)$ always follows the condition $\phi(s) < s + \bar{z}_w$, the denominator is also positive. This implies that $\frac{dw(s)}{ds} > 0$, and so $w(s) > w^I \ \forall s \in (s^*, s_{hi}]$.

Therefore if an informal firm wants to hire a worker with $s \in (s^*, s_{hi}]$, such a worker would cost more than w^I, and have the same MPL as a worker with $s \in [s_{low}, s^*]$ since

$z^I \leq \bar{z}_w$. It is not optimal for any informal firm to make such a choice.

Case 2: $n_w(s,z) > 0$ where $z > z^*$ and $s < s^*$

This is the case of a formal firm hiring a worker with a skill $s \in [s_{low}, s^*]$. Let us assume that there is a task $z' \in [z^*, z^F]$ to which $s' \in [s^*, s_{hi}]$ is currently assigned. I will show that no other worker with skill $s'' \in [s_{low}, s^*]$ can take his/her place at the same or lower marginal cost.

From Equation (1.9), the assignment of skill to task $\phi(s)$ is one that minimises marginal cost. Therefore $\nexists\ s \neq s' \in [s^*, s_{hi}]\ s.t\ mc_w^F(s,z') < mc_w^F(s',z')$. This implies that $mc_w^F(s^*,z') > mc_w^F(s',z')$. Any worker with $s'' \in [s_{low}, s^*]$ will have the same cost of employment w^I as a worker with skill s^* from Equation (1.7), and a lower productivity at task z'. In other words $\psi_w(s'',z') < \psi_w(s^*,z')$. This implies that $mc_w^F(s'',z') > mc_w^F(s^*,z') > mc_w^F(s',z')$.

Therefore, no former firm will employ a worker with skill $s \in [s_{low}, s^*]$ for a task $z \in [z^*, z^F]$.

A.3.3 Matching Function

Producing a unit of a formal good requires completing tasks along the spectrum $\{0, z^F\}$ each b^F times. On an economy wide scale therefore, each of these tasks is done $b^F N^F$ times to produce all the formal goods in the country. If $\bar{L}$ is the total measure of workers in the country, labor market clearing of workers of each skill s implies that

$$\bar{L}h(s) = b^F N^F \int_{z^*}^{z^F} n_w(s,z')dz'$$

Integrating across the spectrum of skill employed by formal firms

$$\bar{L}\int_{s^*}^{s_{hi}} h(s'')ds'' = b^F N^F \int_{s^*}^{s_{hi}} \int_{z^*}^{z^F} n_w(s'',z')dz'ds''$$

Using Lemma 3, it's known that $z = \phi(s)$. This and the definition of $n_w(s,z)$ as the measure of workers of skill s assigned to perform a task of complexity z once implies

that

$$n_w(s,z) = \begin{cases} 0 \quad if \quad z \neq \phi(s) \\ \frac{1}{\psi_w(s,z)} \quad if \quad z = \phi(s) \end{cases}$$

Substituting $z = \phi(s)$ in the equation, and using the Dirac delta function $\boldsymbol{\delta}$ to represent $n_w(s,z)$

$$\bar{L}\int_{s^*}^{s_{hi}} h(s'')ds'' = b^F N^F \int_{s^*}^{s_{hi}} \int_{\phi(s^*)}^{\phi(s_{hi})} \boldsymbol{\delta}\left(\phi(s') - \phi(s'')\right) \frac{1}{\psi_w(s'', \phi(s'))} \phi_s(s')ds'ds''$$

By the definition of the Dirac delta, the inner integral on the RHS collapses and we have

$$\bar{L}\int_{s^*}^{s_{hi}} h(s'')ds'' = b^F N^F \int_{s^*}^{s_{hi}} \frac{1}{\psi_w(s'', \phi(s''))} \phi_s(s'')ds''$$

Differentiating both sides with respect to s'', implies that

$$\phi_s(s'') = \frac{\bar{L}h(s'')\psi_w(s'', \phi(s''))}{b^F N^F}$$

A.4 Computation Appendix

Step 1: Since home is a small open economy, the equilibrium in RoW is not affected by trade with it. It's price index for both final goods, and capital inputs is determined domestically, and $c_{kRoW} = r_{RoW} = 1$. Therefore, it can be independently solved for. It's also taken to be an all formal economy, so there is no s^*_{RoW} to find. The lowest skill worker with skill $s_{low\,RoW}$ is also formally employed. However, z^*_{RoW} has to be found for because tasks are still split between capital and labor in formal firms. I iterate over values of z^*_{RoW} while solving for the following

- By Lemma 3, $\phi(s_{low\,RoW}) = z^*_{RoW}$. Therefore $w(s_{low\,RoW})$ is determined by the no arbitrage condition at the boundary

$$(1+t_w)\frac{w(s_{low\,RoW})}{\psi_w(s_{low\,RoW}, z^*_{RoW})} = \frac{1}{\psi_k(z^*_{RoW})}$$

- Solving for the matching and wage functions, iterations over z^*_{RoW} till $\phi(s_{hiRoW}) = z^F$.

Step 2: From this step onwards, we consider the home economy. Assuming values for s^*_H and w^I_H, I iterate over values of z^*_H.

- Given s^*_H, w^I_H and z^*_H, c^F_{kH} is determined by the no arbitrage condition in Equation (1.10).

- With c^F_{kH} determined, K^F_H is given by

$$K^F_H = \left(\frac{(1-\beta_H)c^F_{kH}}{r^F_H}\right)^{-\sigma_k} \bar{K}_H$$

- With K^F_H and z^*_H known, N^F_H is given by

$$N^F_H = \frac{K^F_H A_k}{b^F\left(z^*_H + \frac{(z^*_H - \bar{z}_k)^{\frac{1}{\nu}+1}}{\frac{1}{\nu}+1}\right)}$$

- With N^F_H, the differential equations for the matching and wage functions given by Equations (1.8) and (1.9) can be solved for and $\phi(s)$, $w(s)$ are known at home.

- Iterations over z^*_H continue till $\phi(s_{hiH}) = z^F$

Step 3: With the matching, and wage functions determined, and c^F_{kH} known the formal task-wise marginal cost functions $\widehat{mc}^F_{wH}(z)$ and $\widehat{mc}^F_{kH}(z)$ can be found. Therefore from Equation (1.11), the marginal cost of producing a good MC^F_H is known. Since the price of a formal good is a straightforward Dixit-Stiglitz markup over this, p^F_H can also be computed. With this $E^F_H = p^F_H * N^F_H$.
Step 4: E_{RoW} and P_{RoW} are computed following Step 1, and $p^F_{HRoW} = \tau p^F_H$. $\bar{\alpha}_{HRoW}$ can be computed using these inputs to satisfy the condition

$$\tau q^F_{HRoW}(\hat{\alpha}_{HRoW})\frac{MC^F_H}{\sigma^F - 1} - S_{HRoW} = 0$$

Step 5: I iterate over E^I_H while solving for the follow

- $\hat{\alpha}_H, \alpha^*_H, \hat{\alpha}_{RoWH}, M_{EH}$ are solved using 4 simultaneous equations which are $\pi^I(\alpha^*) = \pi^F(\alpha^*)$, $\pi^I(\bar{\alpha}) = 0$, $q^F_{RoWH}(\hat{\alpha}_{RoWH})\frac{MC_{RoW}}{\sigma^F - 1} - S_{HRoW} = 0$ and the open economy version of the free entry condition in Equation (1.22). While doing so, I also compute P^I_H and P^F_H using Equations (1.16) and (1.24).

- Iterations over E^I_H till Equation (1.17) is satisfied and the balance of the labor market which is informally employed at home clears.

Step 6: $\hat{w}(s)$ can be computed using Equations (1.19) and (1.20). With that, the expenditure on formal and informal goods can be computed from Equations (1.21). I denote this as $\tilde{E}^F_H$ and $\tilde{E}^I_H$. s^*_H is iterated till these converge to E^F_H and E^I_H which are the values of formal and informal goods produced. If one of these converges, the other has to as well. Steps 2 to 5 are repeated for each new value of s^*_H.

Step 7: w^I_H is varied until home reaches trade balance with RoW. Steps 2 to 6 are repeated for each new value of w^I_H.

A.5 Comparison with CES production

The variables used in this section do not correspond with the rest of the paper. This is only a comparison with an alternative modelling choice, and not relevant to the exposition of the model used

Data: Formal firms are skill intensive, and shift their labor composition further towards skill labor while nearly doubling capital intensity. This occurs as capital costs fall, but skill premiums rise.

Consider the following canonical production function as a candidate for the production framework of formal firms where there are two discrete groups of workers. s denotes skilled labor while u denotes unskilled labor, and k is capital. $\rho < 1$ and $\sigma < 1$. Also μ is small because unskilled labor in formal firms is a smaller fraction of the labor used even before capital costs drop.

$$Y = \left[\mu u^{\sigma} + (1-\mu)\left(\gamma k^{\rho} + (1-\gamma)s^{\rho}\right)^{\frac{\sigma}{\rho}}\right]^{\frac{1}{\sigma}}$$

Define c_s, c_u and c_k as the cost of the three inputs. Let C_{ks} and C be the cost index of the capital, skilled labor pair and C the composite cost index of the inputs. The use of the three inputs is then given by

$$k = \left(\frac{c_k}{\gamma C_{ks}}\right)^{\frac{1}{\rho-1}} \left(\frac{C_{ks}}{(1-\mu)C}\right)^{\frac{1}{\sigma-1}} Y$$
$$s = \left(\frac{c_s}{(1-\gamma)C_{ks}}\right)^{\frac{1}{\rho-1}} \left(\frac{C_{ks}}{(1-\mu)C}\right)^{\frac{1}{\sigma-1}} Y$$
$$u = \left(\frac{c_u}{\mu C}\right)^{\frac{1}{\sigma-1}} Y$$

The relative use of skilled to unskilled labor is

$$\frac{s}{u} = \left(\frac{c_s}{(1-\gamma)C_{ks}}\right)^{\frac{1}{\rho-1}} \left(\mu\frac{C_{ks}}{(1-\mu)c_u}\right)^{\frac{1}{\sigma-1}}$$

The desired outcome is a labor composition shifting towards skilled labor despite a rising cost of skilled labor. A falling cost of capital assists the shift towards skilled labor via capital-skill complementarity (CSC). It is always the case that if c_s is rising as c_k is falling, then $\frac{c_s}{C_{ks}}$ is rising. If the fall in c_k is sufficient, then despite the increase in c_s, it is possible that $\frac{C_{ks}}{c_u}$ is falling. I assume this is the case, because the goal here is to see if a canonical production function with CSC can match the data even under the most favorable of assumptions. For $\frac{s}{u}$ to increase, it is necessary for the rising term in the first bracket to be overwhelmed by the falling term in the second. In other words, it is necessary that $\rho << \sigma$. The lower the ρ, the better it is. Any significant substitutability between capital and skilled labor hampers the shift in skill composition, because then capital will also displace skilled labor whose cost is rising.

The second aspect is to also match the steep rise in capital intensity. Capital intensity is given by

$$\frac{k}{s+u} = \frac{\left(\frac{c_k}{\gamma C_{ks}}\right)^{\frac{1}{\rho-1}}}{\left(\frac{c_s}{(1-\gamma)C_{ks}}\right)^{\frac{1}{\rho-1}} + \left(\frac{(1-\mu)c_u}{\mu C_{ks}}\right)^{\frac{1}{\sigma-1}}}$$

A very low value of $\rho \to -\infty$ immobilizes every term except for $\left(\frac{(1-\mu)c_u}{\mu C_{ks}}\right)^{\frac{1}{\sigma-1}}$. This is not a large term anyway, because μ is low. The most that a fall in capital cost c_k can do is drive this term to zero, resulting in a small increase in capital intensity. This too is hard to achieve, because a lack of substitutability between capital and skilled labor impedes a fall in c_k from driving down C_{ks}. A large increase in capital intensity under these circumstances is nearly impossible.

Appendix B

Export Dynamics, Endogenous Bankruptcy and Financial Constraints

B.1 Model Appendix

B.1.1 Base Model: Computation of default probability

As noted in the main body of the paper, the probability of a firm defaulting on its debt is given by

$$1 - \lambda = Pr(m_{t+1} < D_{t+1})$$

This is easy to assess, because m_{t+1} is distributed normal truncated at m_{max} with a mean that is given by

$$Em_{t+1} = \begin{cases} min\left[m_{max}, R\left(m_t + b_t - D_t + E\pi_t^D(a_t, z)\right)\right] & if\ \ X_t = 0\ \ \&\ \ I_t = 0 \\ min\left[m_{max}, R\left(m_t + b_t - D_t + E\pi_t^D(a_t, z)\right.\right. \\ \qquad\qquad +E\pi_t^X(a_t, z) - S^X & if\ \ X_t = 1\ \ \&\ \ I_t = 1 \\ min\left[m_{max}, R\left(m_t + b_t - D_t + E\pi_t^D(a_t, z)\right.\right. \\ \qquad\qquad +E\pi_t^X(a_t, z, A) & if\ \ X_t = 1\ \ \&\ \ I_t = 0 \end{cases}$$

And a variance that is given by

$$\sigma_m^2 = \begin{cases} \sigma_{\pi^D}^2 \quad if \;\; X_t = 0 \;\; \& \;\; I_t = 0 \\ \sigma_{\pi^D}^2 + \left(\frac{\sigma_{\pi^D}}{\tau^{\sigma-1}}\right)^2 + 2\frac{\sigma_{\pi^D}^2}{\tau^{\sigma-1}} + \sigma_A^2 \quad if \;\; X_t = 1 \;\; \& \;\; I_t = 1 \\ \sigma_{\pi^D}^2 + \left(\frac{\sigma_{\pi^D}}{\tau^{\sigma-1}}\right)^2 + 2\frac{\sigma_{\pi^D}^2}{\tau^{\sigma-1}} \quad if \;\; X_t = 1 \;\; \& \;\; I_t = 0 \end{cases}$$

B.1.2 Model without Endogenous Bankruptcy

With the ability to rollover debt, the only reason a firm defaults on repaying its debt in full is if it is hit by the random death shock δ. Therefore the debt contract offered by creditors for a borrowing of b_t now becomes

$$D_{t+1}(b_t) = \frac{Rb_t - (1-\delta)min[Em_{t+1}, Rb_t]}{\delta}$$

Unlike its counterpart in the base model, this equation does not need to be solved recursively because δ is specified exogenously

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