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CAPITAL ADJUSTMENT PATTERNS AND UNCERTAINTY IN AFRICAN MANUFACTURING

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ABSTRACT

Judging by the provisions of its investment code and the apparent stability of the macro-economy, Ethiopia seems to offer a favourable investment climate for the private sector. However, Ethiopian manufacturing has experienced a declining rate of investment since the mid 1990s. Like other Sub-Saharan African countries, more than half of manufacturing firms in Ethiopia have zero investment episodes; episodes that have become more persistent over time. This contrasts badly with high average profit rates in African manufacturing relative to average profit rates in OECD countries. Rather than being smooth and continuous, firm level investment in Africa is less frequent and lumpy. While this pattern of capital adjustment is not unique to Africa, the discontinuity and lumpiness is starker than what is observed in developed countries. The evidence in this paper suggests that such discontinuity and the lacklustre investment performance have more to do with uncertainty and irreversibility. The paper shows that uncertainty, proxied by the volatility of profits, undermines mainly the likelihood rather than the rate of investment. However, the possibility to reverse investment decisions, captured by the scope of the second hand market for machinery, significantly increases the rate of investment.

Keywords

investment, irreversibility, uncertainty, African manufacturing

CAPITAL ADJUSTMENT PATTERNS AND UNCERTAINTY IN AFRICAN MANUFACTURING

1. INTRODUCTION

The early literature on development economics considers capital formation as the main driver of economic growth. The 'Big-Push' hypothesis for instance underscores the importance of increasing returns to a coordinated large investment in a number of sectors while others focused on investment in a 'lead sector' that would pull the rest of the economy through forward and backward linkages (Rosenstein Rodan 1943; Hirschman 1958; Chenery 1959). For developing countries, investment has also been regarded as the most viable if not the only channel for modern technology from abroad. This near exclusive focus on investment has gradually given way to more balanced views that take into account other aspects of economic growth. For instance, by emphasising the crucial distinction between production systems on the one hand and knowledge and technology systems on the other, the technological capabilities literature asserts that the answer to industrial competitiveness does not lie entirely within the production system (Lall, 2001). New growth and trade theories also focus on innovation and its dynamics for long-term growth in per capita income (Romer 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1998). Although accumulation of capital does not address all the challenges of industrial progress, investment maintains its critical importance in the development process. As a forward looking activity, investment is more than capital accumulation. It involves the formation of expectations about future streams of returns and risk taking by entrepreneurs in an uncertain environment. Investment has also been one of the most volatile components of the macro economy making it an interesting area of research. At the policy level, investment assumes centre stage as structural adjustment programs seek to create and maintain a favourable investment climate that allows the private sector to flourish.

While significant improvement has been made in theoretical models of investment, essentially by incorporate delicate factors such as expectation and uncertainty on top of the usual user costs and aggregate demand, their empirical performance in explaining investment dynamics remains far from satisfactory (Chirinko, 1993). Until recently the empirical literature on investment relied heavily on cross-country studies of gross capital formation and/or time series analysis for individual countries. Firm level analysis of investment behaviour gained new impetus in the past two decades owing to the increasing supply of micro data. This paper contributes to the emerging empirical literature on investment behaviour of African manufacturing firms by probing the capital adjustment patterns of Ethiopian manufacturing firms. The paper investigate the patterns of capital adjustment in Ethiopia and other Africa countries relative to adjustment patterns in the developed world. It also looks at the determinants of investment with a focus on the role of uncertainty and irreversibility. There is already some evidence that African markets are very competitive in selecting efficient firms and that dysfunctional markets are not at the heart of the competitiveness problem for African manufacturing (Fafchamps 1997; Shiferaw, 2005). By revealing key aspects of the capital adjustment pattern and the role of uncertainty, the paper therefore aims to shed more light on the importance of the investment climate for industrial progress.

The paper has the following structure: section two provides background information on the political economy of Ethiopia since the early 1990s with the objective of highlighting key aspects of the investment climate. Section three describes the data. Section four describes capital adjustment patters in Ethiopian manufacturing and compares it with adjustment patters in Europe and other Sub Saharan African countries. Section five analyses the persistence of investment rates based on a one-period transition probability and uses this information to discern between alternative explanations for the observed patterns of adjustment. Section six deals with the determinants of investment: it analyses both the decision to invest and the variation in the rate of investment giving more attention to the role of uncertainty and irreversibility. Section seven uses non-parametric methods to relate investment with Total Factor Productivity. Section eight provides some conclusions.

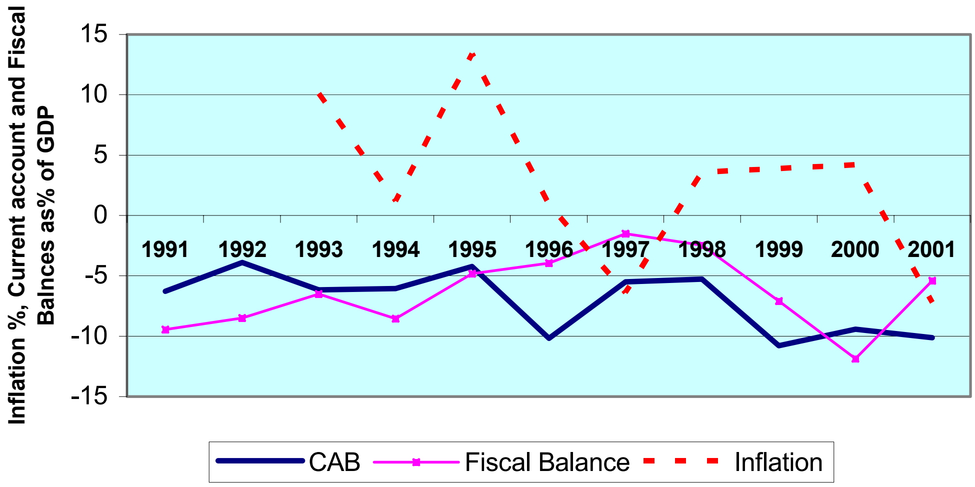
2. THE POLITICAL ECONOMY OF ETHIOPIA

Ethiopia started to implement World Bank/IMF type structural adjustment programs in 1991. This marked the beginning of the country's transition from a centrally planned economy to that of a market economy. The economic reform measures encompass macroeconomic stabilization, trade liberalization as well as some aspects of industrial policy reform. Trade policy reforms included the reduction of import tariffs, elimination or reduction of export taxes, non-tariff barriers and import licensing requirements, as well as the introduction of export promotion schemes. Tariffs were slashed substantially: the maximum tariff was reduced from 240% in 1991/92 to about 40% most recently. The weighted average tariff now stands at about 19% and it is expected to decline as the country adheres to the COMMESA regional trade agreement.

A number of reform measures, which are best described as part of the country's industrial policy, have also been put in place. Most of them are contained in the Investment Law that was first issued in 1992 with subsequent revisions and improvements. These policies aim at enhancing private sector participation by allowing entry into economic activities formerly reserved for the state sector, by removing caps on private investment, and providing a range of incentives including tax holidays. The public enterprises reform act of 1992 was also a key industrial policy reform aiming to place public enterprises on a level playing field with their private sector counterparts (by removing their preferential access to factor inputs) while granting them managerial autonomy.

The macroeconomic environment in Ethiopia has also been fairly stable since the start of the economic reform program in 1991. Figure 1 shows that inflation has essentially been kept in the lower single digits even with few instances of deflation. The fiscal deficit has been reduced steadily from about 10% of GDP to less than 5% except for some relapse during the Ethio-Eritrean border conflict. Although the current account balance has been persistently in deficit, it only shows the country's dependence on aid and does not pose a major threat to macroeconomic stability.

FIGURE 1



Selected macroeconomic indicators of Ethiopia

Source: National Bank of Ethiopia and IMF Country Reports

Another key feature of the macroeconomic environment has been the exchange rate regime, which has increasingly been market driven. Other important measures in connection with private sector development include a new labour law which gives employers more flexibility in managing their labour inputs, the reduction in the time and effort needed to clear imported goods from customs and also to get investment licenses. There has also been a concerted effort to upgrade the country's physical infrastructure particularly of roads and telecommunications with palpable improvements despite the long way these and other infrastructural services have to go to reach satisfactory levels.

Nonetheless, these encouraging developments have at times been overshadowed by uneasy developments in the political economy of Ethiopia. Following the removal of restrictions in the early 1990s, private investment started to pickup pace backed by an accommodating credit flow from the banking sector. In the mid 1990s, however, a number of businesses mainly in the services sector began to experience difficulties in repaying their loans. This raised tension as the non-performing loans of the state owned and largest commercial bank (Commercial Bank of Ethiopia) began to mount. Subsequently, a Bank Foreclosure Law was enacted in 1997 allowing banks to sell mortgaged assets of defaulting firms without having to take them to court. The provision to bypass the legal system may seem pragmatic given the weaknesses of the latter to hand such cases in a timely and orderly manner. However, the law was perceived by private businesses as very tough and unfair as it bestows excessive power on one partner (the banks) of a financial contract. Investors therefore become very cautious about their borrowings which manifested itself in a steady decline of private sector borrowing from 1997 onwards as shown in Figure 2.

Following the border conflict with Eritrea in the late 1990s, a serious political crisis also occurred in 2001 as TPLF (Tigray People Liberation Front), the leading partner in the coalition based ruling party EPRDF (Ethiopian People Revolutionary Democratic Front), was split into two. This apparently internal party affair began to have national repercussions when the Anti-Corruption Law was decreed in 2001 introducing yet another shock to the business sector. The dissenting voices within the party and key figures in the financial and business sectors, who allegedly have connections with them were jailed on the basis of the anti-corruption law few day after it was enacted. For international organizations and donors, including the World Bank and IMF, this move signalled a strong state that is committed to good governance and fighting corruption. Political analysts and the local private media, however, interpreted this incidence as a sure sign of an authoritarian regime that is determined to stamp-out any opposition and that the corruption charges were simply safe and suitable pretexts. While the reality may lie somewhere in the middle, this event has undoubtedly sent a negative shock to the business sector, further dampening an already weak readiness of both banks and businesses to engage in investment related financial transactions. It is interesting to note that since 2001, the excess reserve of commercial banks rose to unprecedented levels while net lending to the private sector slipped into a negative territory. See IMF (2006) and Figure 2 for details.

In a number of other instances too, the expectations of the business sector and the actions of the policy making apparatus in Ethiopia seem to be getting out of symphony. The introduction of VAT in 2003 to replace sales tax was for instance seriously challenged by the business community as an untimely intervention on the grounds of inadequate information infrastructure and the unequal treatment of firms that it entails. Even more serious was the debate between government and the business community about the introduction of the Tax Foreclosure Law which allows the tax authorities to sell business properties, again without a need for court approval, if they fail to pay their taxes. The private sector argued, through its chamber of commerce, that the allowed time for compliance (30 days) is too short given the weak performance of the economy and also in comparison with practices elsewhere. The debate, which was top story during early 2004, ended up with the outspoken leaders of the business community (the president and secretary general of the Addis Ababa Chamber of Commerce) having to flee the country presumably in fear of detention. Ironically, this showdown took place at a time when the country was hosting a highly publicised international trade fare organised by the Addis Ababa Chamber of Commerce. It is with this background, one that encompasses a liberalized and fairly stable macroeconomic condition with apparently tense public-private partnership that the paper analyses the investment dynamics in Ethiopian manufacturing[1].

3. THE DATA

This paper uses a census based panel data of Ethiopian manufacturing firms for the period 1996 to 2002. This dataset is derived from the annual census of manufacturing conducted by the Central Statistical Authority of Ethiopia (CSA) and covers all firms that employ at least 10 persons. The investment rate is defined as total firm level investment as a fraction of the previous year's capital stock. Capital stock is calculated as the capital stock of the initial year plus investment minus depreciation minus capital sales. There is no information on funds put aside by firms for the sake of capital replacement. Depreciation is therefore calculated using a 10% depreciation rate for machinery and vehicles, and 5% for buildings. Profit rate refers to a firm's gross operating surplus calculated by subtracting wages from value added.

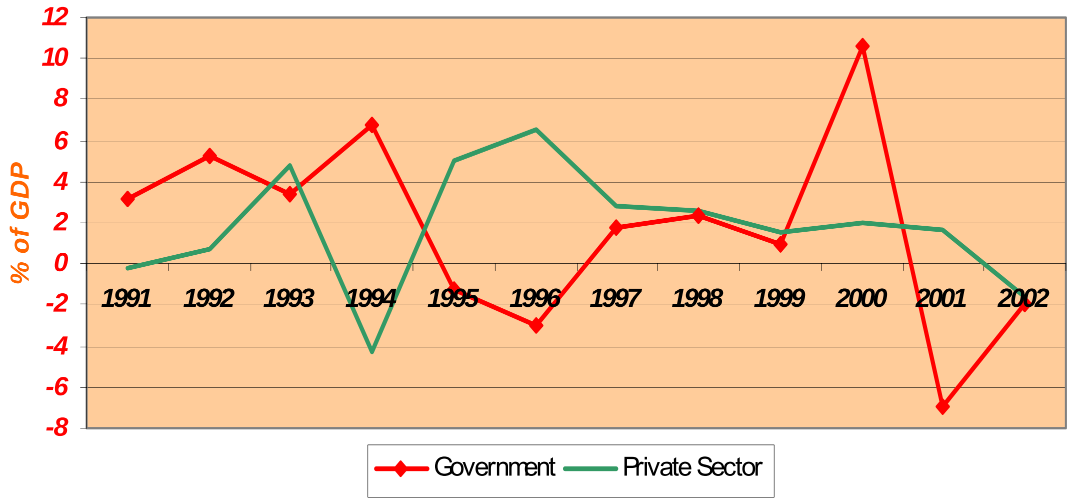
4. CAPITAL ADJUSTMENT PATTERNS

As highlighted in section two, Ethiopia has a very attractive investment code which through a series of revisions has expanded the scope of economic activities and incentives offered to the privates sector. Judging by macroeconomic indicators and the investment code, Ethiopia seems to offer a favourable investment climate by developing country standards.

However, recent trends in private sector borrowing and investment belie the uncertainty underneath the apparently stable macroeconomic environment. Figure 2 shows that despite the stable macroeconomic environment, private sector borrowing from the domestic banking system has been declining especially since 1996. It is interesting to notice that this steady decline comes after the introduction of the Bank Foreclosure Law in 1997/98 which authorizes banks to auction mortgaged assets of defaulting banks. The declining trend seems to have been exacerbated by the 2001 Anti Corruption Law (that implicated several business leaders and bank officials) leading to a negative credit flow to the private sector in 2002. Not surprisingly, during this period commercial banks in Ethiopia have been awash with excess liquidity making it clear that a stable macroeconomic environment does not necessarily induce firms to borrow and banks to lend (IMF, 2005).

[1] The political economy literature is full of instances in which a weak state undermines growth at it fails to organize development and enforce laws. It is quite possible that in some instances, a strong state could also stifle growth as strength leads to self-defeating actions that raise uncertainty (Bates, 2000).

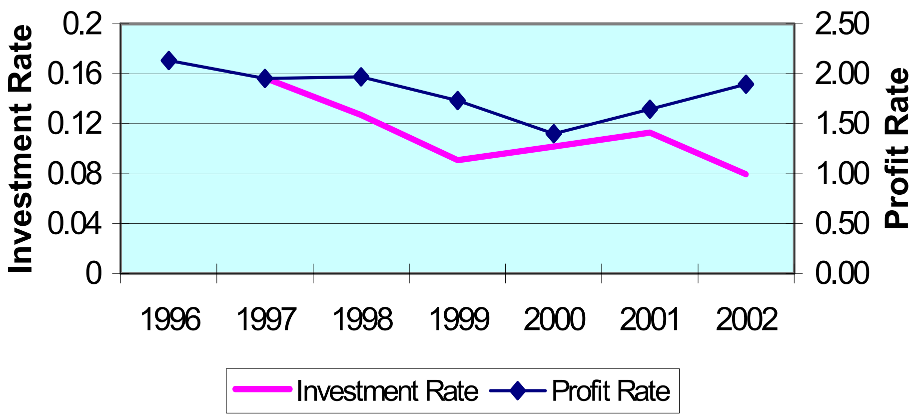
FIGURE 2
Credit to government and the private sector



Source: National Bank of Ethiopia and IMF Country Reports

In line with the recent time path of credit to the private sector, the rate of investment in Ethiopian manufacturing, aggregated from firm level investment, has been declining during the period 1997 to 2002. Figure 3 shows that it has decline from about 16% in 1997 to about 8% in 2002. In the meantime, average profit rates in Ethiopian manufacturing remained very high and comparable to other African countries.

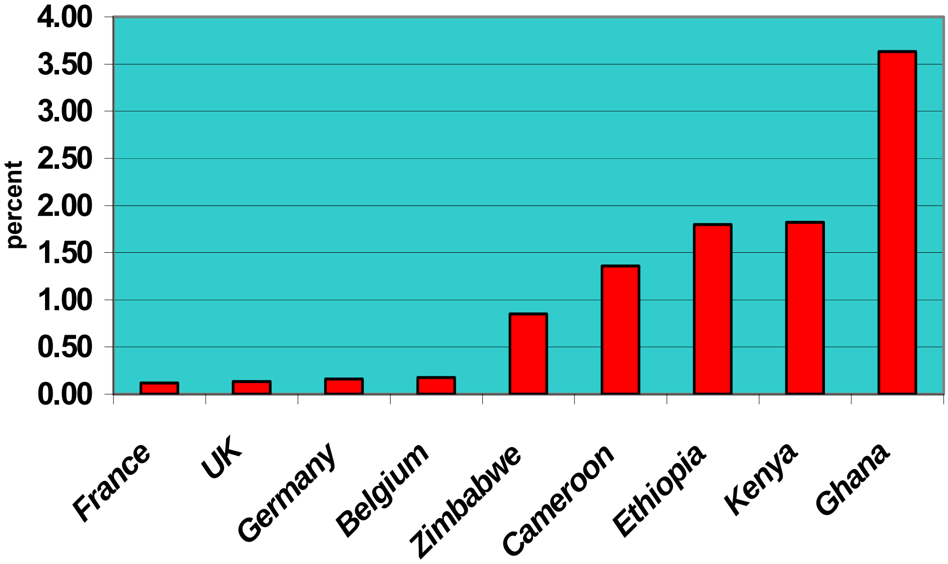
FIGURE 3
Trends in profit and investment rates in Ethiopian Manufacturing



Source: Author's Computation based on CSA's manufacturing Census

The apparent paradox between high profitability and low investment in African manufacturing has also been noted by Bigsten et al. (1999) which is reproduced here for the sake of comparison. Figure 4 compares profit rates for five Sub-Saharan African countries with profit rates for a sample of European countries studied in Bond et al. (1997). It shows that average profit rates in African countries are at least 10 times higher than the rate in European countries, which is about 11%.

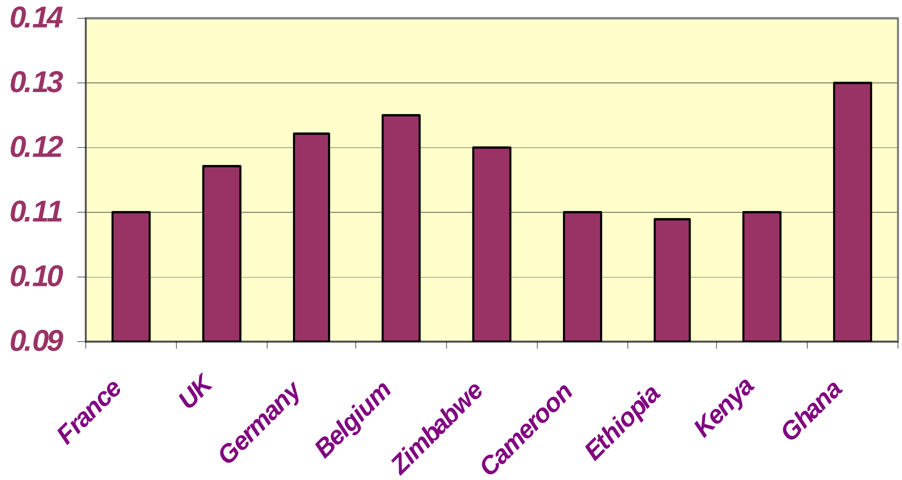
FIGURE 4
Average profit rates in Africa and Europe



Source: CSA for Ethiopia, Bond et al. (1997) for European Countries and Bigsten et al. (1999) for other SSA countries.

On the other hand, Figure 5 shows that the mean investment rate in African manufacturing is comparable if not less than that of EU countries. The first impression from this comparison is that African firms do not plough back their profits in the form of investment, at least not in the same establishment. This behaviour is consistent with an uncertain business environment in which only very high rates of return would trigger firms to invest.

FIGURE 5
Average investment rates in Africa and Europe



Source: CSA for Ethiopia, Bond et al. (1997) for European Countries and Bigsten et al. (1999) for other SSA countries.

Given the information in Figure 6 that the majority of African firms have zero investment at any point in time, the median investment rate in the region is close to zero (Bigsten et al., 1999). This also implies that the mean investment rate among investing firms in Africa must have been very high for the overall average investment rate to level with that of European countries. The major pattern of capital adjustment in African countries therefore combines lumpiness with high incidence of zero investment rates - a pattern to be explored further in the following sections using firm level data from Ethiopian manufacturing.

Table 1 reveals several features of investment in Ethiopian manufacturing. The first point is that on average more than 50% of establishments have zero investment rate (IR=0) during a period of one year and this share has risen in 2002 as compared to 1997. Some industries such as food and beverages, textile and garments, wood and furniture, non-metal, and light-machinery exhibit more than 50% zero investment episodes both in 1997 and 2002. Secondly, about a quarter of firms (21 to 25%) have positive but not more than 10% investment rates. Most of the latter actually have less than 5% investment rate which is likely to be related with minor replacements and maintenance. It appears that about ¾ of manufacturing establishments in Ethiopia have investment rates well below the 10% depreciation rate commonly applied in empirical studies. Finally, only 7-8% of firms fall in the 10-20% investment rate category which would lead to an increase in capital stock. Averaging across industries, about 18% of firms have investment rates in excess of 20% in 1997 although the share of such firms has declined by half to about 10% in 2002. In the remainder of this paper, we refer to investment rates in excess of 20% as lumpy investment or investment spikes. In general, investment does not occur very frequently in Ethiopian manufacturing and when it does, it happens in large spurts that would increase capital stock substantially. This shows the lumpiness of investment which is similar to other developed and developing countries.

TABLE 1
Distribution of gross investment rate by industry

	IR=0		0 <IR≤5%		5<IR≤10%		10<IR≤20%		IR>20%	
	1997	*2002*	*1997*	*2002*	*1997*	*2002*	*1997*	*2002*	*1997*	*2002*
Food & Beverage	57.0	60.1	15.6	17.9	5.5	6.9	7.0	5.2	14.8	9.8
Textile & Garments	53.9	63.3	23.1	23.3	0.0	3.3	3.9	6.7	19.2	3.3
Leather & Foot wear	46.8	41.9	17.0	9.3	10.6	7.0	12.8	27.9	12.8	14.0
Wood & Furniture	58.8	56.0	11.3	23.0	6.3	5.0	8.8	6.0	15.0	10.0
Printing & Paper	43.6	51.7	18.0	20.7	2.6	10.3	5.1	1.7	30.8	15.5
Chemical & Plastic	32.6	42.2	13.0	26.6	4.4	9.4	15.2	6.3	34.8	15.6
Non-Metal	61.4	56.7	8.8	23.3	8.8	10.0	7.0	5.0	14.0	5.0
Metal	46.4	43.2	21.4	29.6	3.6	13.6	10.7	6.8	17.9	6.8
Machinery	58.8	53.9	17.7	23.1	0.0	7.7	5.9	7.7	17.7	7.7
Total	52.6	54.2	15.4	21.3	5.3	7.6	8.3	7.0	18.4	9.9

Source: Author's computation based on CSA's Manufacturing Census. Note: The numbers add to 100 across columns for 1996 and 2002. Investment rate is the ratio of current investment to lagged capital stock.

TABLE 2
Distribution of gross investment rate by firm size

	IR=0		0 < IR ≤ 5%		5 < IR≤ 10%		10<IR≤20%		IR>20%	
	1997	*2002*	*1997*	*2002*	*1997*	*2002*	*1997*	*2002*	*1997*	*2002*
Small	68.7	69.7	9.5	14.2	4.0	5.2	5.1	4.6	12.7	6.4
Medium	46.2	50.4	23.1	23.7	2.2	7.2	8.8	6.5	19.8	12.2
Large	22.7	22.6	22.7	34.9	10.2	13.7	14.8	13.0	29.7	15.8
Total	52.6	54.2	15.4	21.3	5.3	7.6	8.3	7.0	18.4	9.9

Source: Author's computation based on CSA's Manufacturing Census.

Table 2 shows that the proportion of firms with zero investment declines with firm size. The share of establishments with zero investment declines from more than 2/3 among small firms to less than a quarter among large firms. It appears that small and medium size firms account for most of the increase in the incidence of zero investment in 2002 across industries. On the other hand, lumpy investment is more likely to occur among large firms as compared to small and medium size firms. This divergence in the lumpiness of investment by firm size is less stark in 2002 as the incidence of lumpy investment declined drastically in all size categories. The main observation is that most of the zero investment episodes occur at the lower end of the firm size distribution while lumpy investment occurs frequently at the upper end of the distribution. It is also important to note that peripheral investment (below the depreciation rate) is relatively more frequent among large firms as compared to small and medium size firms. The latter situation coupled with the inverse relation of zero investment with firm size implies that capital adjustment is relatively smoother among large firms.

Disaggregated Investment

On average, about 56% of total capital stock in Ethiopian manufacturing consists of machinery and equipment, while buildings and vehicles account for about 38% and 6%, respectively. Table 3 explores the rigidity in the adjustment of these three categories of capital. In terms of investment, on average 46% of total investment during 1996-2002 was in machinery, about 40% in buildings and 15% in vehicles. As shown in the table, aggregation tends to reduce the rigidity in capital adjustment as the relative frequency of zero investment is much higher for disaggregated items as compared to aggregate firm level investment. For instance, the incidence of zero investment for aggregate investment is 53% while it is 66% for machinery and about 84% for buildings and vehicles. This is to be expected as aggregate investment will be positive if a firm invests in at least one of the three capital items. In all investment categories, the zero investment episode declines with firm size while the incidence of investment spikes (IR>20%) increases with size. Irrespective of firm size, capital adjustment in machinery tends to be relatively smoother than investment in buildings and vehicles where zero investment episodes are rampant. The incidence of zero investment in buildings and vehicles is about 20 percentage points higher than that of machinery. While the general pattern is the same in the three categories of investment, the difference among them has probably more to do with their relative importance for the production process rather than reflecting differences in capital adjustment costs in the three categories.

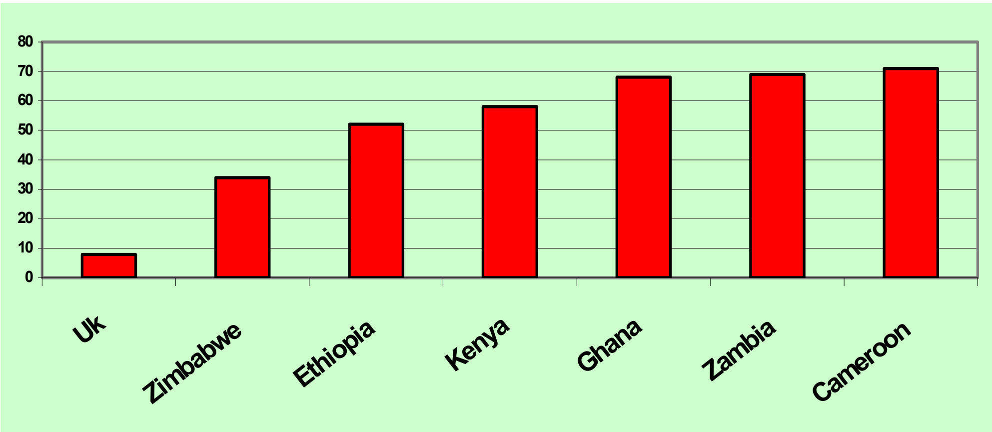
TABLE 3
Distribution of disaggregated investment by firm size

	IR=0	0< IR≤5%	5 < IR≤ 10%	10<IR≤20%	IR>20%	Total
Machinery						
Small	79.7	7.0	3.5	2.9	6.9	100
Medium	62.8	13.0	5.1	4.6	14.6	100
Large	35.8	30.8	7.7	10.3	15.4	100
Total	65.8	13.9	4.8	5.0	10.6	100
Building						
Small	92.2	2.3	1.0	1.2	3.3	100
Medium	82.8	7.9	1.6	2.1	5.5	100
Large	64.9	17.1	4.1	3.2	10.8	100
Total	83.7	7.0	1.9	1.9	5.5	100
Vehicle						
Small	96.3	0.8	0.3	0.2	2.5	100
Medium	84.1	1.4	1.6	1.9	11.0	100
Large	56.1	6.8	4.1	4.3	28.8	100
Total	84.2	2.3	1.5	1.5	10.5	100
Aggr. Investment						
Small	70.0	12.7	4.2	4.3	8.9	100.0
Medium	46.0	23.5	7.1	7.8	15.7	100.0
Large	20.0	32.8	12.6	11.9	22.7	100.0
Total	53.0	19.8	6.8	6.8	13.6	100.0

Note: Numbers are for the entire period 1996-2002 across all industries.
Source: Author's Computation Based on CSA's Manufacturing Census

How do these observations compare with investment patterns in other countries? For UK manufacturing, Attanasio, Pacelli and Reis (2000) find zero investment episodes of 58%, 25% and 2.3% for buildings, vehicles, and machinery, respectively. While the prevalence of zero investment particularly in buildings and vehicles is broadly similar in both countries, the sheer frequency of zero investment in Ethiopian manufacturing lays bare the difficulties of capital accumulation African firms encounter. Very high fixed adjustment costs and uncertainty are some of the major culprits emphasised in the literature. Looking at aggregate investment, the share of firms with lumpy investment in Ethiopia is 13.6% which is more than twice the corresponding figure for UK (5.4%).

FIGURE 6
Proportion of manufacturing firms with zero investment rates



Source: CSA for Ethiopia, Bond et al. (1997) for European Countries and Bigsten et al. (1999) for other SSA countries.

For a group of five Sub-Saharan African countries, Bigsten et al. (2005) find that a vast majority of firms have zero investment rates which are even higher than in Ethiopia. See Figure 6. Based on the RPED data for the early 1990s, they find that 71% of firms in Cameroon, 69% in Zambia, 68% in Ghana, 58% in Kenya, and 34% in Zimbabwe have zero investment rates[2]. They also report that among those firms with positive investment, 27% of them have investment rates in excess of 20% for data pooled across the five countries. This is equivalent to about 11.3% (27% of 42%) of the total number of firms in the full sample - including those firms with zero investment- which is comparable to the share of firms with investment spikes in Ethiopian manufacturing, i.e. 13.6%. These findings suggest that manufacturing firms in

[2] That is why the medina investment rate has been zero for in another study which includes only four of the five countries Bigsten et al. (1999).

Sub-Saharan Africa face very high fixed adjustment costs and/or uncertainty as compared to developed countries.

Contribution of Investment Spikes

Compared to developed countries, lumpy investment is more frequent and accounts for a major part of total investment in Sub-Saharan Africa .

Table 4 indicates that, although there are few firms with investment rates in excess of 20% (Tables 1 to 3), they account for the bulk of total investment in Ethiopian manufacturing during the period 1996-2002. About 73% of total investment in machinery, 81% of investment in buildings and close to 90% of investment in vehicles occurs as lumpy investment. Taken together, establishments with investment spikes (13.6% of total) account for 71% of total investment showing the importance of lumpy investment in capital adjustment. The extent of lumpiness is higher for buildings and vehicles as compared to investment in machinery. On the other hand, peripheral investment accounts for only 18% of total investment in Ethiopian manufacturing. It is also clear from Table 4 that investment by large firms is relatively less lumpier as compared to small and medium size firms.

TABLE 4
Share of investment by categories of investment rate (%)

	IR=0	0< IR≤5%	5 < IR≤ 10%	10<IR≤20%	IR>20%
Machinery					
Small	1.8	2.9	6.6	88.6	
Medium	2.3	3.6	7.3	86.8	
Large	7.7	8.1	16.8	67.5	
Total	6.2	6.8	14.2	72.9	
Building					
Small	4.1	2.0	6.4	87.5	
Medium	5.5	2.2	10.2	82.0	
Large	6.5	8.2	4.9	80.4	
Total	6.1	6.4	6.2	81.3	
Vehicle					
Small	0.5	1.3	1.1	97.1	
Medium	0.4	1.8	4.3	93.4	
Large	1.0	4.1	6.7	88.2	
Total	0.9	3.8	6.3	89.0	
Total Investment					
Small	4.0	4.6	10.3	81.1	
Medium	4.4	5.5	8.3	81.8	
Large	7.4	13.5	10.6	68.4	
Total	6.7	11.7	10.2	71.3	

Source: Author's computation based on CSA's Manufacturing Census

Lumpy investment also accounts for the lion's share of total investment in other countries. In the UK, Attanasio et al. (2000) find that 61% of total investment in building, 58.5% of investment in vehicles and 26.5% investment in machinery is accounted for by few firms with lumpy investment.

Irrespective of investment kinds, firms with investment spikes (5.4% of total) account for 24.6% of total investment in the UK manufacturing. Similarly, Dune and Domes (1997) report that 25% of total investment in US manufacturing is accounted for by firms with lumpy investment. While the importance of lumpy investment in overall capital adjustment is evident in developed countries as well, it is far less prominent than what is observed in African manufacturing.

For the five Sub-Saharan African countries mentioned above, Bigsten et al. (2005) show that firms with lumpy investment (IR>20%) account for 47% of total investment which is nearly twice the rate in the UK and US. The fact that the role of lumpy investment is much higher in Ethiopian manufacturing (71% of total), as compared to other SSA countries reviewed here has more to do with differences in sample composition. The Ethiopian data is based on a manufacturing census that covers all firms that employ at least 10 persons (and hence dominated by small firms) while the RPED data often over-samples large firms. As the preceding discussion has made it clear, capital adjustment is relatively smoother among large firms.

5. PERSISTENCE OF INVESTMENT

Zero investment episodes need not necessarily be a problem unless they persist. One way of checking persistence in investment rates is to trace the one-year transition probability of investment rates. Table 5 provides such transition probabilities for investment in machinery and equipment for two sub-periods (the pattern for total investment basically reflects that of machinery). The table shows that zero investment episodes have very high probability of being repeated in the next period. About 78.7% of those firms with zero investment in machinery in any year during 1997-1999, would have zero investment in the following year too. The likelihood of zero investment recurring in the next period is very high among small firms at about 86% declining to about 68% among medium size firms and to 60% among large firms. Such tenacity of zero investment episodes has actually increased during the period 2000 to 2002 except for a slight decline among small firms. This shows that not only is the proportion of firms with zero investment very high in Ethiopian manufacturing, the recurrence of zero investment conditional on zero investment in the current period has also increased.

Ignoring size differences, firms with non-zero investment in the current period are more likely to have positive investment in the next period. This does not apply for small firms in which case more than 50% of those with positive investment in the current period would have zero investment in the next period. For instance, during 1997-1999, 80.7% of small firms with 0<IR<5% have zero investment rate next period. The propensity to investment next period conditional on positive investment in the current period increases with firm size. Among medium size firms for instance more than 50% of firms with positive investment in the current period are likely to undertake some investment next year. The transition from positive to zero investment falls substantially in the case of large firms as they tend to invest more or less continuously.

TABLE 5
One period transition probability of machinery investment rate

	1997-1999					
	IR=0	0< IR≤5%	5< IR≤10%	10< IR≤20%	IR>20%	Total
All Firms						
IR=0	78.7	8.8	3.5	2.5	6.5	100
0< IR≤5%	43.7	34.9	4.0	6.4	11.1	100
5 < IR≤ 10%	30.0	27.5	10.0	10.0	22.5	100
10<IR≤20%	27.7	29.8	2.1	10.6	29.8	100
IR>20%	31.9	20.2	10.1	12.6	25.2	100
Small						
IR=0	86.3	4.4	2.7	2.5	4.1	100
0< IR≤5%	80.7	12.9	0.0	0.0	6.5	100
5 < IR≤ 10%	38.5	15.4	23.1	7.7	15.4	100
10<IR≤20%	55.6	11.1	0.0	0.0	33.3	100
IR>20%	51.4	8.1	5.4	10.8	24.3	100
Medium						
IR=0	68.6	13.2	4.1	2.5	11.6	100
0< IR≤5%	52.4	19.1	4.8	0.0	23.8	100
5 < IR≤ 10%	50.0	25.0	0.0	0.0	25.0	100
10<IR≤20%	40.0	20.0	0.0	10.0	30.0	100
IR>20%	40.6	12.5	15.6	15.6	15.6	100
Large						
IR=0	60.2	21.7	6.0	2.4	9.6	100
0< IR≤5%	25.7	48.7	5.4	10.8	9.5	100
5 < IR≤ 10%	6.7	40.0	6.7	20.0	26.7	100
10<IR≤20%	14.3	39.3	3.6	14.3	28.6	100
IR>20%	12.0	34.0	10.0	12.0	32.0	100

	2000-2002					
	IR=0	0< IR≤5%	5< IR≤ 10%	10< IR≤20%	IR>20%	Total
All Firms						
IR=0	80.5	7.9	2.7	2.7	6.1	100
0< IR≤5%	36.7	32.0	8.2	8.2	15.0	100
5 < IR≤ 10%	40.7	15.3	13.6	15.3	15.3	100
10<IR≤20%	40.0	30.9	12.7	5.5	10.9	100
IR>20%	43.7	16.0	9.2	12.6	18.5	100
Small						
IR=0	84.2	5.1	2.8	2.1	5.8	100
0< IR≤5%	62.5	22.5	5.0	7.5	2.5	100
5 < IR≤ 10%	50.0	9.1	9.1	13.6	18.2	100
10<IR≤20%	73.3	13.3	13.3	0.0	0.0	100
IR>20%	64.3	11.9	9.5	4.8	9.5	100
Medium						
IR=0	81.6	6.8	2.0	0.0	9.5	100
0< IR≤5%	48.4	22.6	3.2	3.2	22.6	100
5 < IR≤ 10%	38.5	15.4	23.1	15.4	7.7	100
10<IR≤20%	43.8	25.0	18.8	0.0	12.5	100
IR>20%	41.0	12.8	10.3	7.7	28.2	100
Large						
IR=0	62.0	22.8	3.3	9.8	2.2	100
0< IR≤5%	18.4	40.8	11.8	10.5	18.4	100
5 < IR≤ 10%	33.3	20.8	12.5	16.7	16.7	100
10<IR≤20%	16.7	45.8	8.3	12.5	16.7	100
IR>20%	23.7	23.7	7.9	26.3	18.4	100

Source: Author's Computation Based on CSA's Manufacturing Census

There is also some degree of persistence in lumpy investment although it is far less tenacious than the zero investment episodes. Regardless of firm size, there is 25% likelihood for investment spikes to recur during 1997-1999. Interestingly, about 30% of firms with investment rates between 10% to 20% are also likely to have an investment spike the next period. This shows that periods of large investment occur in close proximity as are periods of zero investment although at a lower level of persistence.

However, the likelihood of having another round of high investment next period conditional on large investment in the previous period has declined in the period 2000 to 2002. Averaging across industries, the persistence has gone down from 25% to 18%. This includes sharp declines from 32% to about 18% for large firms and from 24% to just about 10% for small firms. The slowdown of capital accumulation in Ethiopian manufacturing documented in Figure 3 is therefore associated with the increase in the incidence of zero investment coupled with the decline in the recurrence of lumpy investment. It is interesting to note that the standard deviation of investment rate within a firm overtime is 30% higher than the standard deviation of investment rate across firms at any point in time. This is to be expected given the increase in the incidence of zero investment episodes over time (increasing the discontinuity of investment) while the frequency of lumpy investment declines (reducing the spread of investment rate across firms). Apart from its immediate impact on growth of manufactured output, poor investment performance would damage the competitiveness of the manufacturing sector as the introduction of new products or new varieties of existing products often requires investment in new machinery and equipment.

TABLE 6
Incidence of positive firm level investment (1997-2002)

Counts of positive investment	Small (%)	Medium (%)	Large (%)	All Firms (%)
1	42.8	22.0	8.6	27.7
2	30.0	19.4	6.6	20.6
3	13.5	18.0	9.1	13.2
4	7.5	15.0	14.8	11.4
5	4.0	11.1	13.0	8.3
6	2.3	14.6	47.9	18.7
Total	100	100	100	100
Firm –Years	1501	768	950	3219

Source: Author's Computation Based on CSA's Manufacturing Census

Another way of exploring persistence is to see how often each firm invests during a particular time interval. Table 6 shows that on average 43% of small firms invest only once during the period 1997-2002 while another 30% invest twice. Only few small firms (less that 5%) invest continually. On the other hand, 48% of large firm invest throughout the sample period with less than 10% of them investing only once. Because of the predominance of small firms in the sample, nearly half (48.3%) of all manufacturing firms have positive investment for not more than two out of six years. Other thins being equal, the rate of investment is unlikely to increase as the size distribution of firms continues to shift to the left. There are no important industry specific differences in this pattern.

Persistence, Adjustment Costs and Irreversibility

What lies behind the discontinuity of capital adjustment documented so far? Theoretical models of investment assume that firms do not achieve their desired stock of capital for several reasons including adjustment costs. The latter include but are not limited to output forgone during machine installation and costs arising due to mandatory training of staff. Traditional investment models assume convexity of capital adjustment costs whereby the latter rise exponentially with the magnitude of adjustment. The implication of convexity is that firms would prefer to spread out their investment over time (in small lots) to avoid large adjustment costs. According to such models, we expect neither periods of zero investment nor investment spikes; capital adjustment would rather be smooth and continuous. Obviously, the adjustment patters we observed so far in Ethiopia and other Sub-Saharan African countries do not conform to the predictions of convex adjustment costs. Convexity also does not fit capital adjustment patterns in developed countries (Caballero, et al., 1995; Domes and Dunne, 1998; Cooper, et al., 1999)

Recent studies of investment behaviour pay a lot of attention to irreversibility of investment and non-convexity of adjustment costs. Both features seem to have their own implications on capital adjustment patterns and some frameworks of analysis have been developed to identify their relative importance (Abel and Eberly, 1994; Caballero and Engel, 1999). If investment decision is partly or fully irreversible because of missing markets for second hand machinery, investors would be more cautious and wait for more information on expected returns before committing themselves to an investment project (Dixit and Pindyck, 1994; Bertola and Caballero, 1994). Given the possibility to delay investment outlays, waiting for more information allows investors to avoid costly mistakes in case an irreversible project turns unprofitable. Keeping the option to productively invest in the future has therefore a value which enters the opportunity cost of investment (exercising the option). This option value tends to increase with uncertainty hence undermining investment by raising its opportunity cost. In such circumstances, there would be periods of inaction (zero investment or disinvestment) during which a firm does not respond to changes in desired stock of capital. While irreversibility seems to explain why there would be episodes of zero investment, it does not necessarily imply that once firms decide to invest their investment would be lumpy.

On the other hand, if adjustment costs are fixed rather than convex, firms would prefer to delay investment to avoid incurring fixed adjustment costs repeatedly (Caballero and Engel, 1999). Fixed adjustment costs also imply that firms would prefer to invest in large amounts with intervals of zero investment. Such discontinuity of investment is therefore a rational response to increasing returns associated with fixed adjustment costs. Both irreversibility and fixed adjustment costs therefore seem to predict capital adjustment patterns in Sub-Saharan Africa better than quadratic adjustment costs.

While irreversibility and non-convexity of adjustment costs both predict zero investment, they have different implications regarding the propensity to invest conditional on current investment. In the case of irreversibility, the probability to invest in the next period is higher for firms that have positive investment in the current period as compared to those firms with zero investment. This follows from the assumption that the firm has got sufficient information to resolve the uncertainty. In the language of duration analysis the hazard (probability) of investment follows positive duration dependence if investment is difficult to reverse. In the case of fixed adjustment costs however, the probability to invest in the next period is higher for firms with zero rather than positive investment in the current period. In this case the hazard of investment follows negative duration dependence (Cooper et al., 1999; Goolsbee and Gross, 2000).

Although duration models offer the best way to investigate these phenomena, Table 5 provides useful information to distinguish between irreversibility and fixed adjustment costs. Firms with zero investment in the current period are more likely to have zero investment next period while firms with positive investment are more likely to have positive investment in the next period too. Firms with investment rates in excess of the 10% depreciation rate have particularly high propensities to have positive or even lumpy investment in the next period. The capital adjustment pattern in Ethiopia therefore seem to be consistent with the expected adjustment patterns with irreversibility and uncertainty rather than high fixed adjustment costs. Using duration analysis, Bigsten et al. (2005) find evidence in support of irreversibility although this evidence does not distinguish irreversibility from quadratic adjustment cost. Appendix 1 provides further analysis on investment response to changes in desired stock of capital.

6. DETERMINANTS OF INVESTMENT

Having looked at investment patterns, we now turn to investigate some of its determinants. The analysis starts by looking at what determines the decision to invest as most firms in Ethiopia do not invest at any point in time. A binary choice model is thus used to analyse the probability of investment. Subsequently, a standard Euler equation is deployed to analyse variation in the rate of investment.

Most empirical models address some elements of three major blocks of determinants of investment: quantity factors, price factors and shocks. For a review of standard investment models see Jorgenson (1971) and Chirinko (1993). The quantity factors often refer to change in demand and access to finance. The former drives change in the desired stock of capital while the latter determines the firm’s ability to respond to it. Price factors on the other hand refer to capital goods prices, taxes and interest rates that affect the user cost of capital. Shocks include a number of unobserved factors such as idiosyncratic random shocks which are unknown both to the firm and the researcher, and technology and productivity changes which are known to the firm but hard to observe for the researcher. They also include volatilities in quantity and price factors which in principle are observable both to the researcher and the firm.

Although the main objective of investment models is to explain variation in the rate of investment, for African economies like Ethiopia, explaining the incidence of zero investment is also important because of the prevalence of zero or practically zero investment rates. The dependent variable is therefore a dummy variables which takes the value one if the firm invests and zero if not. The probability model to be estimated includes output growth and profit rate as explanatory variables representing changes in demand and the financial position of the firm. Unlike previous empirical studies the probability model to be estimated also controls for firm level efficiency. This would allow us to assess the extent to which capital is being allocated toward efficient firms. The discussion in section four already suggests that firm size is positively associated with the propensity to invest. The size effect often operates through quantity factors particularly in relation to access to external finance. However, it may also work through productivity shocks arising from scale advantages or better access to technology. We also include firm age, industry, and location effects to parameterise the model.

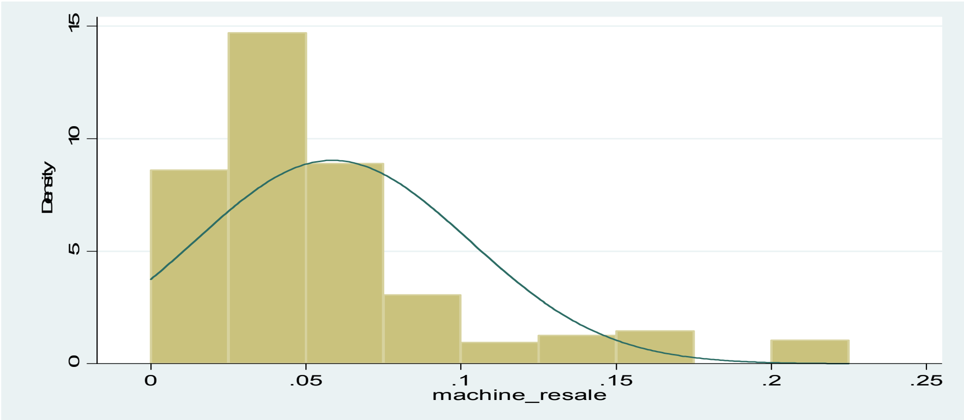
Compared to quantity and price factors which have been researched extensively (albeit with limited success), emphasis on shocks as potential determinants of investment has only began recently. Irreversibility of investment decision received prime importance in recent theories of investment because of the option value of waiting which increases with uncertainty. There are two implications associated with this approach. The first implication is that uncertainty increases the rate of return that triggers investment if investment is hard to reverse. The traditional decision rule of undertaking investment when the net present value is at least zero is not any more applicable under irreversibility and uncertainty. The other implication is that irreversibility and uncertainty reduce the responsiveness of firms to changes in the desired stock of capital. There will thus be a range of inaction (in terms of rates of return) within which the firm does not invest or disinvest.

Empirical studies are only gradually catching up with developments in theoretical models that deal with irreversibility and uncertainty. The main challenge in operationalising these investment models lies in measuring uncertainty and irreversibility. Most of existing empirical studies use a panel of countries to assess the effect of uncertainty often measured in terms of volatility of macroeconomic variables such as inflation, the term of trade, and exchange rate. For a sample of 84 developing countries of which 40 are from Sub Saharan Africa, for instance, Serven (1998) finds a significantly negative effect of macroeconomic volatility on investment. Similar results were reported by Hadjimichael and Ghura (1995) for a sample of 32 African countries.

Econometric tests with firm level data are even more scarce and Pattillo (2000) has been among the first to do so for an African economy. Based on RPED data for Ghanaian manufacturing firms, she measured uncertainty as the inter-firm variation (within an industry) in the one-year-ahead expected change in demand. The idea behind this approach is that a high degree of variation among firms regarding expectation of future demand would indicate high uncertainty. To capture reversibility, she used the information whether a firm has leased a capital good, or sold or bought one from a second hand market. She finds a negative effect of uncertainty only for firms whose investment is irreversible. While interesting and innovative, this approach has been criticised for potentially serious mismeasurement of uncertainty and reversibility. In discussing Pattillo's (2000) paper, Gunning (2000) argues that the real question regarding reversibility is not whether a firm actually leased or sold a capital item at a point in time; what is important is whether it has the option to do so. Therefore two firms investing on identical machines could be wrongly categorized as having different degrees of reversibility if one of them has sold/bought a second hand machine in the current period and the other does not. Regarding uncertainty, firms within an industry may expect, with certainty, widely different rates of change in demand for their respective products - in which case the uncertainty measure of Pattillo would overstate the risk. In another extreme case, firms in an industry may expect demand shocks with little inter-firm variation, in which case the Pattillo measure would understate or even miss the uncertainty as the standard deviation of expected change in demand would be close to zero (Gunning, 2000).

To alleviate these measurement problems, a slightly different approach is followed in this paper. The degree of reversibility of investment is approximated by the scope of the second hand market in a four digits industry. Assuming that this structural feature does not change rapidly over time (for which there is some evidence), the scope of the second hand market is measured by the frequency of machine resale during the study period. The idea is that the higher the fraction of firms in an industry that engage in machine resale, the higher the possibility to reverse investment. In this case, even if a firm does not actually use the second hand market, the existence of a functioning market increases the reversibility of investment and hence their propensity to invest. Three categories have been identified: industries where the incidence of machine resale is less than 5%, between 5% to 10%, and more than 10%. Dummy variables *Sechand1, Sechand2 and Sechand3* represent these categories respectively in the regression models. The decision of cut-off points is admittedly ad-hoc and based on a visual inspection of the empirical distribution. The distribution of machine resale representing the scope of the second hand market is shown in Figure 7. To measure uncertainty, a three-year moving standard deviation of sales and profit rates are calculated for each firm. Variable *Sales SD* and *Profit SD* represent volatilities in sales and profit, respectively. The assumption is that volatility in these variables would capture uncertainty. This measure is problematic since part of the movement in sales and profits could be the result of conscious business decision rather than purely unexpected exogenous change. However, if a good part of variation in profits is the result of firms' deliberate actions, then it should be associated positively with the rate of investment rather than the expected negative relationship.

FIGURE 7
The frequency distribution of machine resale



Source: Author's Computation Based on CSA's Manufacturing Census

Table 7 reports the results of a probit regression model. The results indicate that change in the rate of profit does not significantly affect the likelihood of investment. This result may seem odd but it is consistent with our previous observation that most firms do not invest in spite of high profit rates. This is unlike the finding of Bigsten et al. (1999) where they find that the propensity to invest increases with profitability. Interestingly, output growth and firm level productivity are positively associated with the probability of investment after controlling for size, age and industry specific effects. This shows the importance of demand and relative efficiency in influencing the propensity to invest. As would be expected, the probability model confirms the positive association between investment and firm size (measured as the logarithm of employment) as documented in the descriptive analysis. Older firms on the other hand are less likely to invest as compared to young ones.

The results also show that the volatility of profit rate (*Profit SD*) has a statistically significant negative effect on the propensity to invest. Although profit rate may not induce firms to invest, its predictability seems to have an important role. Interestingly, reversibility captured by the scope of the second hand market increases the likelihood of investment. This effect is statistically significant in cases where the second hand market involves more than 10% of firms *(Sechand3*). The interaction of reversibility with volatility of profits does not significantly reduce the negative effect of uncertainty. The coefficient of volatility of sales and its interaction with reversibility is practically zero. The main message from the probability model is that uncertainty in terms of volatile profits dampens the likelihood of investment while the existence of second hand market tends to increase firms' willingness to invest. However, the negative effect of uncertainty on investment is not significantly different across industries with varying degrees of reversibility.

TABLE 7
The Probability of Investment (Probit Model Estimates)

	Coefficient	Standard Errors
Profit Rate (t-1)	0.0159	0.0118
Output Growth (t-1)	0.0769*	0.0458
Productivity (t)	0.1101***	0.0392
Firm Size	0.6291***	0.0555
Firm Age	-0.0089**	0.0040
Profit SD	-0.0616*	0.0341
Sales SD	0.0000**	0.0000
Sechand 2	0.2333	0.1930
Sechand 3	0.7364***	0.2440
Sechhand2*Profit SD	0.0150	0.0390
Sechand 3*Profit SD	0.1002	0.1311
Sechhand2*Sales SD	0.0000*	0.0000
Sechand 3*Sales SD	0.0000	0.0000
Textile & Garments	-0.7790***	0.2480
Leather & Footwear	0.2470	0.2102
Wood & Furniture	0.0192	0.2218
Printing & Paper	0.6413***	0.1951
Chemical & Plastic	0.1873	0.1988
Non-Metal	0.1151	0.1889
Metal	0.0985	0.2474
Machinery	-0.4466	0.3651
Intercept	-2.5443***	0.2165
Wald Chi-square (p-value)	273.36	
sigma_u	0.8527	0.0706
Rho	0.4210	0.0404
Number of observations	2297	
Number of groups	698	

Note: statistical significance at 1%, 5% and 10% are represented by ***, ** and *, respectively.

The Euler Equation

Models that explain the rate of investment traditionally come in two flavours: models with implicit and explicit dynamics (Chirinko, 1993). The basic neoclassical model suggested by Jorgenson (1971) is typical of investment models with implicit dynamics. The model is based on a desired capital with the following structure:

$$K_t^* = \alpha Y_t C_t^{-\sigma} \quad (1)$$

where K_t^* is the desired stock of capital, Y_t is output (the quantity variable), and C_t is the cost of capital which includes price variables such as interest rate, price of capital goods and taxes, and σ is the elasticity of substitution between capital and variable inputs. The investment model is arrived at by splitting investment into net investment and replacement investment. As summarized in Chiriniki (1993, 1878), net investment is determined through distributed lag on new orders which equal in a given period the change in the desired capital stock while replacement investment is determined by assuming a constant depreciation rate on initial capital.

$$I_t^n = \sum_{j=0}^{J} \beta_j \Delta K_{t-j}^* \tag{2}$$

$$I_t^r = \delta K_{t-1} \tag{3}$$

where I_t^n and I_t^r are net and replacement capital, β_j represent the delivery lag distribution over J+1 periods, and δ is the depreciation rate. The neoclassical model is obtained by combining equation (1), (2) and (3) and adding a stochastic term:

$$I_t = \delta K_{t-1} + \sum_{j=0}^{J} \alpha \beta_j \Delta \left(Y_{t-j} C_{t-j}^{-\sigma} \right) + u_t \tag{4}$$

If the elasticity of substitution $\sigma = 0$, one gets the flexible accelerator model although the basic neoclassical assumption is that $\sigma = 1$. Despite its popularity, the neoclassical models in (4) and other variants of it have been criticised on several grounds (Chirinko, 1993). Perhaps the most important critique relates to the distributed lags for net-investment for which there is not theoretical foundation. Related to this is the static nature of expectations in neoclassical models which is based on extrapolation of past values of output and user costs. The firm in these models therefore does not need to look carefully into the future which is incompatible with the forward looking nature of investment decisions. There is therefore a general preference among researchers for investment models with explicit dynamics.

Models with explicit dynamics try to overcome this shortcoming by including the dynamic elements of the investment process directly into to the firm's optimization problem. Tobin's *q*, and the Euler equation are popular among these models. In these models the firm is assumed to maximize the discounted sum of expected cash flows subject to adjustment costs. In the q-theory of investment, unobserved expectation of future cash flows are related to observables based on the values of the firm in financial markets (Tobin 1969, 1978). While Tobins-q is a popular investment model partly because of the ease to get stock-market prices, their empirical performance has been disappointingly poor. Its application to developing country firms is also hampered by the absence of stock markets or the limited number of listed firms even when they exist. Some of its assumptions such as separation of the investment decision from financial decisions are also untenable in the context of developing counties. For the latter two reasons, the paper follows the Euler equation approach which has a limited (one year ahead) but forward looking behaviour with convex adjustment costs.

The Euler equation is a structural model based on the following optimization behaviour (Bond and Meghir, 1994).

$$Y_t = F\left(L_t, K_t\right) \tag{5}$$

$$\Pi_t = p_t F\left(L_t, K_t\right) - p_t G\left[I_t, K_t\right] - w_t L_t - p_t^I I_t \tag{6}$$

where Y_t is output, $F\left(L_t, K_t\right)$ represents a production function homogenous of degree one, Π_t is gross profit, *L* and *K* are labour and capital, I_t is investment, p_t is output price, p_t^I is price of capital goods, w_t is wage rate.

Given a quadratic adjustment cost function of the form:

$$G\left[I_t, K_t\right] = \frac{1}{2} bK \left[\left(I/K\right)_t - c\right]^2,$$

the objective of the firm is to maximize the following value function:

$$V\left(K_{t-1}\right) = \underset{\{K,L\}}{Max}\left\{\Pi\left(L_t, K_t, I_t\right) + \beta_{t+1} E\left[V_{t+1}\left(K_t\right)\right]\right\} \tag{7}$$

where β_{t+1} is the discount factor and E is the expectations operator. This objective function is subject to capital accumulation of the perpetual inventory approach:

$$K_t = I_t + \left(1-\delta\right) K_{t-1} \text{ Where } \delta \text{ is the rate of depreciation.} \tag{8}$$

Maximization of equation (7) yields the following investment model:

$$\left(\frac{I}{K}\right)_{t+1} = \beta_0 + \beta_1\left(\frac{I}{K}\right)_t - \beta_2\left(\frac{I}{K}\right)_t^2 - \beta_3\left(\frac{\Pi}{K}\right)_t + \beta_4\left(\frac{Y}{K}\right)_t + d_{t+1} + \eta_i + u_{t+1} \tag{9}$$

Three estimation methods are considered: the OLS estimator, the within estimator and the GMM estimator. Although the within estimator deals with firm fixed effects, the GMM estimator is the preferred method as it deals with the endogeneity problem more effectively in the presence of the lagged dependent variable in the RHS.

The regression results are reported in Table 8. Across all estimators, lagged investment has a positive and statistically significant correlation with current investment except for the within estimator which gives a negative coefficient for medium size firms. This finding is in agreement with the persistence of investment documented earlier. According to the GMM estimator, which is the preferred estimator, profit rates are statistically significant only for investment by small firms. In the empirical literature on investment, profit rates are often interpreted as capturing the effect of financial market imperfection while other prefer to interpret them as a proxy for future profitability. If profit serves as an indicator of expected profitability rather than financial market imperfection, one would not expect heterogeneity in its effect across firms of different size. The regression results are however supportive of imperfection in credit markets where small firms are more reliant on their internal funds as compared to medium and large firms. For medium and large firms, change in output has a significantly positive effect underlining the importance of demand factors.

TABLE 8
Estimates of Euler equation model: dependent variable is I_t / K_{t-1}

	Small			Medium			Large		
	OLS	Within	GMM	OLS	Within	GMM	OLS	Within	GMM
$\left(I_{t-1} / K_{t-2} \right)$	0.24874*** (0.06087)	0.20854*** (0.06204)	1.13399*** (0.1027)	0.29425*** (0.072)	-0.16889* (0.08006)	1.19319*** (0.22089)	0.47040*** (0.06651)	0.159 (0.0835)	1.518*** (0.213)
$\left(I_{t-1} / K_{t-2} \right)^2$	-0.06709** (0.02561)	-0.24491*** (0.02665)	-0.63033*** (0.04103)	-0.10452*** (0.03043)	0.0212 (0.03183)	-0.58488*** (0.09637)	-0.14948*** (0.0266)	-0.100** (0.033)	-0.661*** (0.080)
$\left(\Pi_t / K_{t-1} \right)$	0.01027* (0.00471)	0.01793** (0.00584)	0.03490*** (0.00782)	-0.01126 (0.00699)	-0.04911*** (0.00847)	-0.04352*** (0.01261)	0.00507 (0.00516)	-0.013* (0.006)	-0.016 (0.009)
$\left(\Delta Y_t / K_{t-1} \right)$	-0.00092 (0.00153)	-0.00632* (0.00303)	-0.01283** (0.00411)	0.00894*** (0.00248)	0.03989*** (0.00488)	0.04301*** (0.00731)	0.00846*** (0.00186)	0.030*** (0.00324)	0.035*** (0.005)
Constant	0.03225 (0.02368)	0.09799*** (0.02364)	0.00362 (0.00985)	0.10350** (0.0339)	0.09233* (0.03662)	-0.02940* (0.01424)	0.08793** (0.03044)	0.02894 (0.03469)	-0.006 (0.013)
Sargan Statistic			29.58181			27.928			47.40
Sargan p-value[1]			0.000			0.000			0.000
No. Instruments			18			18			18
No. Observations	1140	1140	719	522	522	362	629	629	479
No. Groups		408	284		155	129		148	137
R-Square	0.025	0.204		0.0697	0.227		0.183	0.238	

[1] The p-value of the Sargan test rejects the restrictions on the instrument matrix of the GMM estimator which means that the instruments are not dealing with the endogeneity problem effectively. The same applies to the results in Table 9.
Note: statistical significance at 1%, 5% and 10% are represented by ***, ** and *, respectively.

The basic Euler equation is then extended by including indicators of uncertainty. We use here the volatility of profit and its interaction with the scope of the second hand market. GMM estimates of this extended model are reported in Table 9. The findings discussed earlier are unaltered by the inclusion of uncertainty and irreversibility: investment is path dependent and small firms rely on internal funds more than medium and large firms. The results show that uncertainty of future profit has a negative but insignificant correlation with investment. Therefore uncertainty tends to influence the decision to invest rather than the level of investment. However, the interaction of uncertainty with the scope of the second hand markets has a positive and statistically significant coefficient. This suggests that firms which have more options to reverse their investment have higher rates of investment for a given level of uncertainty. This result does not hold when the regression is restricted to medium and large firms.

TABLE 9
GMM estimates of investment under uncertainty

	All Firms	Small	Medium	Large
$\left(I_{t-1}/K_{t-2}\right)$	1.4693***	1.1440***	1.2885***	1.5474***
	(0.1006)	(0.1047)	(0.2337)	(0.2135)
$\left(I_{t-1}/K_{t-2}\right)^2$	-0.7156***	-0.6327***	-0.6322***	-0.6851***
	(0.0400)	(0.042)	(0.1023)	(0.0810)
$\left(\Pi_{t}/K_{t-1}\right)$	0.0012	0.0347***	-0.0441***	-0.0157*
	(0.0057)	(0.0079)	(0.0129)	(0.0094)
$\left(\Delta Y_{t}/K_{t-1}\right)$	0.0113***	-0.0126***	0.0428***	0.0293***
	(0.0033)	(0.0042)	(0.0076)	(0.0057)
	-0.0121	-0.0057	-0.0530	-0.0035
Profit SD	(0.0147)	(0.0156)	(0.0335)	(0.0385)
	0.0146	0.0028	0.0550	0.0312
Sechand2 * Profit SD	(0.0176)	(0.0205)	(0.0363)	(0.0448)
	0.0933***	0.3524*	0.0950	0.0599
Sechand3 * Profit SD	(0.0248)	(0.2156)	(0.0901)	(0.0451)
	-0.0127*	0.0012	-0.0318**	-0.0021
Intercept	(0.0072)	(0.0098)	(0.0141)	(0.0126)
Sargan Statistic	62.1200	63.0500	23.0600	39.6900
Sargan p-value	0.0000	0.0000	0.0060	0.0000
M1 (p-value)	0.0000	0.0000	0.0000	0.0000
M2 (p-value)	0.5190	0.2670	0.6870	0.1510
No. Observations	1537	838	360	478
No. Groups	539	265	128	137

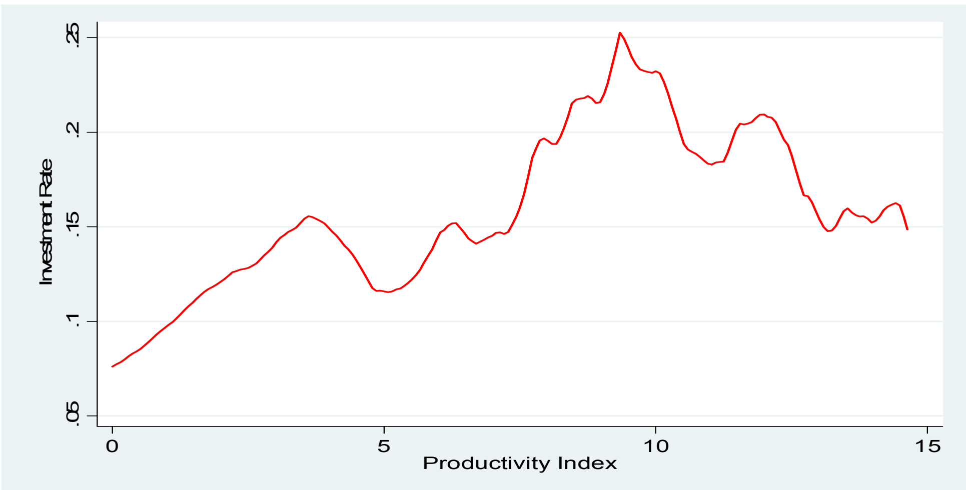
Note: statistical significance at 1%, 5% and 10% are represented by ***, ** and *, respectively

7. INVESTMENT AND TOTAL PRODUCTIVITY

How does investment relate to productivity? The market selection literature suggests that firms with positive productivity shock respond to it with investment. In fact theories of market selection are essentially dynamic theories of investment. Firm level Total Factor Productivity (TFP) is estimated as a residual from a value added production function using the Levinsohn and Petrin (2003) semi-parametric estimation method. Notwithstanding the Ackerberg et al. (2005) critique, this method addresses the simultaneity problem by using variation in intermediate inputs as a proxy for unobserved heterogeneity. Shiferaw (2005) provides details on the estimation procedure and calculation of TFP.

Figure 8 shows a bi-variate non-parametric regression of investment rate on firm level productivity. The regression line plots the conditional mean investment rate using the Nadaraya-Watson kernel estimator. The graph shows that investment increases with firm level efficiency in a non-linear fashion. It indicates that efficient firms are in a better position to take up investment opportunities arising in an industry.

FIGURE 8
Investment and productivity in Ethiopian manufacturing (1997-2002)
Nadaraya-Watson non-parametric regression



Source: Author's Computation Based on CSA's Manufacturing Census

The evidence in Figure 8 is supported by the statistics in Table 10. The table compares the productivity raking of firms in 1997 with their subsequent investment rates. The table shows that the fraction of firms with investment spikes increases with efficiency. Among firms in the top productivity quintile in 1997, nearly a quarter (23.7%) have investment spikes in subsequent years and this fraction declines to less than 10% in the bottom quintile. On the contrary, 64% of firms in the bottom quintile in 1997 have zero investment in the ensuing years which declines steadily to about one-third among firms in the top quintile. Interestingly, most entrants since 1997 also have zero investment until 2002. Productive firms are therefore more likely to have investment spikes while inefficient firms are more likely to have zero investment episodes. Apparently, entrants are also not investing aggressively which is consistent with such firms being relatively small in size and also of their uncertain position in the market.

TABLE 10
Distribution of Investment Rate By Productivity Ranking

Productivity quintiles in 1997	Rank	IR>20%	10<IR≤20%	5 < IR≤ 10%	0< IR≤5%	IR=0	Total (%)
	1	23.7	10.6	9.9	23.2	32.6	100
	2	14.3	8.6	8.2	19.9	49.1	100
	3	12.3	5.5	7.2	20.0	55.0	100
	4	12.2	6.9	6.0	15.6	59.3	100
	5	8.5	4.3	4.8	18.0	64.4	100
	Entry	9.1	4.7	4.4	20.3	61.6	100

Note: Number of observations is 3431 firm-years. Numbers add to 100 row wise.
Source: Author's Computation Based on CSA's Manufacturing Census

What about the impact of investment on productivity? Figure 9 shows that investment lagged by one period has a positive relationship with current productivity although the productivity effect is less evident for extremely large investment rates. We observe that current productivity provides a signal for desired investment while current investment raised future productivity.

FIGURE 9
Productivity and investment in Ethiopian manufacturing (1997-2002)
Nadaraya-Watson non-parametric regression

Source: Author's Computation Based on CSA's Manufacturing Census

TABLE 11
Initial investment and subsequent productivity ranking

Investment in 1997	Productivity quintiles in 2002					Exit	Total
	1	2	3	4	5		
IR>20%	30.8	22.0	18.7	8.8	5.5	14.3	100.0
10<IR≤20%	34.2	26.8	14.6	2.4	2.4	19.5	100.0
5 < IR≤ 10%	3.9	26.9	23.1	15.4	3.9	26.9	100.0
0< IR≤5%	30.3	14.5	11.8	7.9	6.6	29.0	100.0
IR=0	13.9	11.9	11.2	7.7	8.5	46.9	100.0

Note: Number of observations is 494 firms
Source: Author's Computation Based on CSA's Manufacturing Census

Table 11 provides additional evidence about the relationship between investment and productivity. Perhaps the most consistent and interesting observation from Table 11 is that the fraction of exiting firms declines steadily with the rate of investment. Among firms with lumpy investment in 1997 only 14% exited the market before 2002 while the corresponding exit rate among firms with zero investment is 47%. This indicates that investment tends to increase the survival probability of firms (Shiferaw, 2005). The message is not so clear at the top of the productivity distribution. About 31% of firms with lumpy investment in 1997 have been found in the top productivity quintile in 2002 as compared to 14% among firms with zero investment. About 30% of firms with positive but less than 5% investment rate have also been observed in the top quintile in 2002 blurring the relationship between investment and relative efficiency. Further investigation however shows that these are large firms which are likely to have other sources of efficiency. The general message is that firms that do not engage in investment are more likely to exit. This could be either because lack of investment reduces the relative efficiency of firms subsequently leading to exit, or firms which realize that they are relatively inefficient refrain from investing and continue to operate until the moment is reached when it is worthwhile to close down.

8. CONCLUSIONS

Like other Sub-Saharan African countries, high profit rates in Ethiopian manufacturing do not translate into high investment rates; at least not in the same establishment. Episodes of zero investment have been observed in more than half of the manufacturing establishments at any point during the study period. Capital adjustment takes place mainly in the form of large discrete jumps rather than through smooth increments. As a result, more than 2/3 of total investment across industries is accounted for by lumpy investment by few establishments. The rigidity of capital adjustment is severe among small firms where the incidence of zero investment is rampant.

Adjustment patterns in Ethiopia are very much similar with patterns in other Sub Saharan African countries except for differences arising from size composition of samples. While investment in a sample of European countries also shows lumps and bumps, its discontinuity is far less than what is observed in African. African firms reviewed in this paper invariably show profit rates several times higher than their European counterparts although their investment performance is disproportionately low. Uncertainty and the difficulty to reverse investment decisions play an important role in dampening firm level investment in African manufacturing. The prevalence and persistence of zero investment documented in the one-period transition probability is consistent with a pattern of capital adjustment (or lack thereof) expected under uncertainty and irreversibility. Regression results reveal that the probability of investment is higher in industries where the scope of the second hand market is broader. Similarly, uncertainty arising from volatility of profits has a negative influence on the propensity to invest although the level of profits itself is not so important. Uncertainty however does not seem to have a significant effect on the rate of investment while firms with options to reverse their investment are shown to have higher investment rates.

The level of profit has a positive and significant effect on investment among small Ethiopian firms, a common observation in most developing countries. The standard interpretation that small firms rely more on internal funds for investment as compared to large firms also seems to apply here. Such imperfection in financial markets and the need for small firms to accumulate sufficient internal funds coupled with the indivisibility of capital items provide additional explanation for the sharp discontinuity of investment among small firms. The obvious policy implication is to improve the accessibility of modern financial services to small businesses. Private sector borrowing from the banking system in Ethiopia has however been declining in recent years. The drop in credit flow to the private sector has more to do with recent development in the political economy of the country as documented in the section two. Policy moves such as the introduction of the Bank Foreclosure Law and the Anti-Corruption Law were followed by sharp declines in credit to the private sector demonstrating the sensitivity of the investment climate to such measures. The downside of such swift and apparently legitimate policy measures is that they signal an uncertain and non-cooperative business-government relationship. The result is a decline in the aggregate investment rate underpinned by the increase in the incidence of zero investment and a decline in the incidence of firms with investment spikes. Therefore while inter-firm and inter-industry differences in irreversibility and volatility of profits may explain firm level variation in investment, the time path of aggregate capital accumulation seems to be driven by broader developments in the political economy.

Another important empirical regularity documented by productivity analysis in developed and developing counties is the persistence of efficiency at the top of the distribution. This paper goes further to show some of the reasons for such persistence. The fact that productivity increases the likelihood of investment and investment in turn boosts efficiency with a lag enables efficient firms to retain their relative position. Such interdependence between efficiency, investment and innovation keeps efficient firms at the top of the productivity distribution. Most exiting firms on the other hand are not only inefficient, but they also do not invest. If inefficient firms do not invest because they realize their inefficiency upon entry, their exit would enhance aggregate efficiency as capital gets reallocated to more efficient producers. However, to the extent that small entrants fail to invest because of financial constraints and/or uncertainty discourages incumbents from undertaking investment, the resulting loss of efficiency would reduce aggregate productivity and exit of potentially successful businesses. The paper finds evidence of an investment process that is losing momentum over time but still is consistent with market principles. The policy implication is therefore to maintain the functionality of markets to ensure efficient allocation of resources while reducing financial imperfections and business uncertainty to induce firms to invest. Sensitivity to the implications of policy changes on business confidence is particularly important as very bold steps are as likely to create uncertainty as weakness to take action.

REFERENCES

Abel, A. and J. Eberly (1994) "A Unified Model of Investment Under Uncertainty." *American Economic Review* 84(5): 1369-84.

Ackerberg, Daniel A., Kevin Caves and Garth Frazer (2005) "Structural Identification of Production Functions." Mimeo, Yale Department of Economics, Yale University.

Arellano, M. and S. Bond (1991) "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *Review of Economic Studies* 58: 277-97.

Attanasio, O., L. Pacelli, and I. dos Reis (2000) " Investment Patterns in UK Manufacturing Establishments." Mimeo, Institute of Fiscal Studies.

Athey, J. M. and P.S. Laumas (1994) " Internal Funds and Corporate Investment in India." *Journal of Development Economics* 45: 287-303.

Bates, H. Robert (2000) "So What Have We Learned?" In *Investment and Risk in Africa*, eds. P. Collier and C. Pattillo. London: Macmillan Press.

Bertola, G. and R. Caballero (1994) "Irreversibility and Aggregate Investment." *Review of Economic Studies* 61: 223-46.

Bigsten, A., P. Collier, S. Dercon, M. Fafchamps, B. Gauthier, J.W. Gunning, R. Oostendorp. C. Pattillo, M. Soderbom and F. Teal (2005) "Adjustment Costs and Irreversibility as Determinants of Investment: Evidence from African Manufacturing." *The B.E. Journals in Economic Analysis and Policy* 4(1): 1-29.

Bigsten, A., P. Collier, S. Dercon, M. Fafchamps, B. Gauthier, J.W. Gunning, A. Isaksson, A. Oduro, R. Oostendorp. C. Pattillo, M. Soderbom, M. Sylvain, F. Teal, and A. Zeufack (1999) "Investment in Africa's Manufacturing Sector: A Four Country Panel Data Analysis." *Oxford Bulletin of Economics and Statistics* 61: 489-512.

Bo, H. and Z. Shang (2002) "The Impact of Uncertainty on Firm Investment: Evidence from Machinery Industry in Liaoning Province of China." *Economic Systems* 26: 335-52.

Bond, S. and C. Meghir (1994) "Dynamic Investment Models and the Firm's Financial Policy." *Review of Economic Studies* 61: 197-222.

Bond, S., J. Elston, J. Mairesse, and B. Mulkay (1997) " Financial Factors and Investment in Belgium, France, Germany and the UK: A Comparison using Company Data." *NBER Working Paper* No. 5900.

Caballero, R., E. Engel, and J. Haltiwanger (1995) "Plant-Level Adjustment and Aggregate Investment Dynamics." *Brookings Papers on Economic Activity* 2: 1-39.

Caballero, R. and E. Engel (1999) " Explaining Investment Dynamics in US Manufacturing: A Generalised (S,s) Approach." *Econometrica* 67: 783-826.

Carruth, A., A. Dickerson, and A. Henley (2000) " What Do We Know About Investment Under Uncertainty?" *Journal of Economic Surveys* 14(2): 119-53.

Chenery, H.B. (1959) "The Interdependence of Investment Decisions," in M. Abramovitz (ed.), *The Allocation of Economic Resources*. Stanford, CA: Stanford University Press.

Chirinko, R. (1993) "Business Fixed Investment Spending: Modelling Strategies, Empirical Results, and Policy Implications." *Journal of Economic Literature* 31(4): 1875-1911.

Collier, P. and C. Pattillo (eds) (2000) *Investment and Risk in Africa*. London: Macmillan Press.

Cooper, R., J. Halitwanger, and L. Power (1999) "Machine Replacement and the Business Cycle: Lumps and Bumps." *American Economic Review* 89(4): 921-946.

Dixit, A.K. and R.S. Pyndyck (1994) *Investment Under Uncertainty*. Princeton NJ: Princeton University Press.

Doms, M. and T. Dunne (1998) "Capital Adjustment Patterns in Manufacturing Plants." *Review of Economic Dynamics* 1: 402-429.

Fafchamps, M. (1997) "Introduction: Markets in Sub-Saharan Africa." *World Development* 25(5): 733-734.

Goolsbee, A. and D. Gross (2000) "Estimating Adjustment Costs with Data on Heterogeneous Capital Goods." Mimeo, University of Chicago.

Gunning, J.W. (2000) "Discussion on 'Risk, Financial Constraints and Equipment Investment in Ghana: A Firm-Level Analsis' by Catherine Patillo." In Collier and Patillo (eds): *Investment and Risk in Africa*, London: Macmillan Press.

Hadjimichael, M., D. Ghura, M. Muhleisen, R. Nord and E.M. Ucer (1995) "Sub Saharan Africa: Growth, Savings and Investment, 1986-93." *International Monetary Fund Occasional Papers*, No. 118.

Hirschman, A. (1958) *Strategy of Economic Development*. New Haven, CT: Yale University Press.

IMF (2006) "The Federal Democratic Republic of Ethiopia: Selected Issues and Statistical Appendix." *IMF Country Report No 06/122*, IMF: Washington D.C.

Jaramillo, F., F. Schiantarelli and A. Weiss (1996) "Capital Market Imperfections before and after Financial Liberalization: An Euler Equation Approach to Panel Data for Ecuadorian Firms." *Journal of Development Economics* 51: 367-386.

Jorgensen, Dale W. (1971) "Econometric Studies of Investment Behaviour: A Survey." *Journal of Economic Literature* 9(4): 1111-47.

Lall, S. (2001) *Competitiveness, Technology and Skills. Edward Elgar , UK.*

Levinsohn, James, and Amil Petrin (2003. "Estimating Production Functions Using Inputs to Control for Unobservables." *Review of Economic Studies* 70(April): 317-341.

Pattillo, C. (2000) "Risk, Financial Constraints and Equipment Investment in Ghana: A Firm-level Analysis." In *Investment and Risk in Africa*, eds. P. Collier and C. Pattillo. London: Macmillan Press.

Pindyck. R. (1988) "Irreversible Investment, Capacity Choice and the Value of the Firm." *American Economic Review* 78(3): 969-85.

Rosenstein-Rodan, P.N. (1943) "Problems of Industrialization of Eastern and South-Eastern Europe." *Economic Journal* 53 (June-September).

Shiferaw, A. (2006) " Entry, Survival and Growth of Ethiopian Manufacturing Firms." ISS Working Paper No. 425 , Institute of Social Studies, The Hague.

Shiferaw, A. (2007) "Firm Heterogeneity and Market Selection in Sub-Saharan Africa: Does it Spur Industrial Progress?" *Economic Development and Cultural Change (Forthcoming)*

Tybout, J. (1983) "Credit Rationing and Investment Behaviour in Developing Countries." *Review of Economics and Statistics* 65(4): 598-607.

APPENDIX: DESIRED CAPITAL AND INVESTMENT

Further analysis was carried out to assess firm response to changes in desired stock of capital. In line with the approach suggested by Caballero, Engel and Haltiwanger (1995) mandated investment was calculated as the difference between desired and actual capital stock.

$$\text{MI}=\tilde{k}_{it}-k_{it-1} \tag{1}$$

where MI is mandated investment, and $\tilde{k}_{it}$ and k_{it-1} is log of desired and actual capital. Following Caballero et al. (1995) desired capital is assumed to be a certain proportion of frictionless capital k_{it}^{*}.

$$\tilde{k}_{it}=k_{it}^{*}+d_i \tag{2}$$

where d_i is a plant or industry specific constant.

The frictionless capital is k_{it}^{*} is determined using user cost of capital and output as in the standard neoclassical approach. This gives us the following expression:

$$k_{it}^{*}=k_{it-1}+\eta_i\left[\left(y_{it}-k_{it-1}\right)-\theta_i c_{it}\right] \tag{3}$$

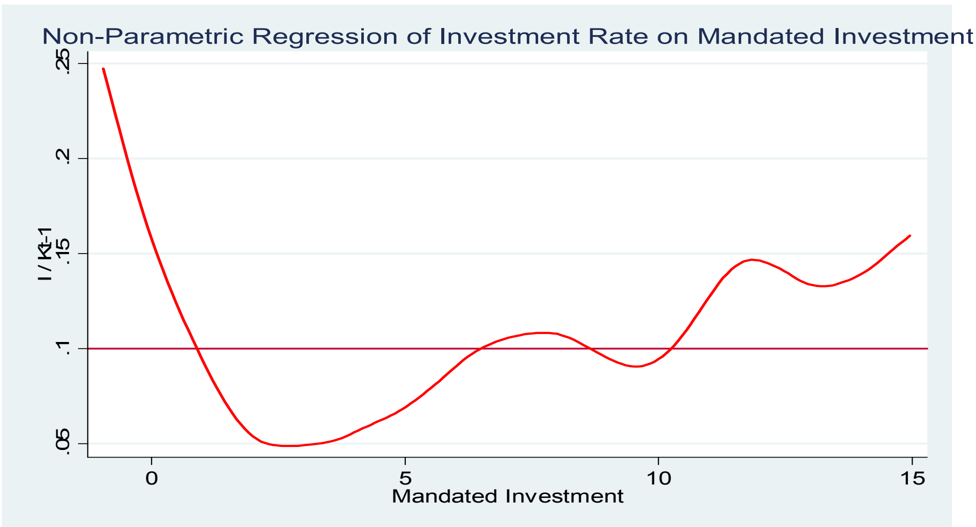
where $\eta_i = 1/(1-\alpha_i)$ is the slop of the profit function with respect to capital and α_i is the cost share of equipment capital.

$$c_{it}=\left(r+\delta_i\right)\left(PI_t/p_{it}\right)/\left(1-\tau\right) \tag{4}$$

where r the real lending rate (lending rate minus inflation) δ_i is the depreciation rate, PI_t is the price index of capital goods and p_{it} is firm specific price index and τ is the profit tax rate. PI_t is approximated by the import unit price of machinery imports to Ethiopia assuming that the composition of machines imported to the country and its technological content remained stable during the study period. Once c_{it} is calculated, then θ_i is estimated from a regression of the natural logarithm of capital-to-output ratio on cost of capital and the coefficient of c_{it} will be interpreted as the long-run elasticity of capital with respect to cost of capital. This has been done for each industry separately and it has been found to be negative and statistically significant. Finally desired capital is estimated by adding a constant d_i to frictionless capital which in this case is the industry specific median investment rate. Note that desired capital is the capital the firm wants to have if there are no adjustment costs while frictionless capital is the capital the firms desires if adjustment costs are temporarily removed.

Then the actual investment rate is regressed against mandated investment using the Nadaraya-Watson Kernel estimator following the approach in Goolsbee and Gross (2000). According to Caballero and Engel (1999) suggest that in the presence of fixed adjustment cost, average investment increases with mandated investment in a non-linear fashion with a range of inaction at lower level of discrepancy between desired and actual capital. Under irreversibility Bigsten et al. (2005) show that the relationship between actual and mandated investment is linear outside the range of inaction. A tentative result is given below.

APPENDIX Figure 1



Source: Author's Computation Based on CSA's Manufacturing Census

Appendix Figure 1 shows the Nadaraya-Watson kernel regression of investment rate on mandated investment. The graph does not show a range of inaction expected under irreversibility and fixed adjustment costs. It however indicates that firms respond to large discrepancies between desired and actual capital in a non-liner fashion which would be the case under fixed adjustment costs.