Should I Stay or Should I Go: Investor Protection, Firm Dynamics and Aggregate Productivity

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Abstract

The large cross-country variation in income per capita is mainly accounted for by total factor productivity and is highly correlated with various measures of investor protection. To account for these patterns, I propose a theory based on firm selection. Improvements in investor protection, reduce disproportionally the risk-premium of entrant firms augmenting the value of starting a project anew. This increase in the outside option of an incumbent, raises the exit rate of lower quality firms improving overall productivity. Quantitative exercises indicate that this selection mechanism accounts for around 25 percent of the observed cross-country patterns in aggregate productivity. Additionally, the model provides novel predictions for which I document empirical support. I show that firms start smaller and grow faster in countries with worse investor protection, and that the number of young firms and the speed of deleverage are increasing with investor protection. Finally, I show that the optimal punishment for default is decreasing in the quality of investor protection.

JEL Classification Codes: E6, F3, G1, L0

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1 Introduction

The large cross-country variation in income per capita is mainly accounted for by the difference in total factor productivity (TFP). A large strand of the literature points to the strong correlation between financial and economic development as indication that the former may cause the latter by promoting a more efficient allocation of resources. In this paper I analyze the cross-country differences in recovery rate, an indicator of investor protection, and propose a novel theory of aggregate TFP based on firm selection.

In economies with better recovery rate the risk-premium demanded on younger and riskier firms is relatively low which increases both the debt and the size of an entry firm, along with the value of starting a new business. This higher outside option allows lower quality firms to select themselves out of the market to restart a new project. Conversely, in countries with low recovery rate the risk-premium on younger firms, relative to established entrants, is much higher reducing the initial firm size and consequently the outside option of closing a project to start a new one. This selection mechanism appears to be supported by the data. Using comprehensive firm-level data on 28 European countries, I find that in economies with high recovery rate, older firms are relatively more productive than young ones. On the other hand, in countries with lower recovery rates this pattern is almost non-existent. For example in an economy with a recovery rate in the top-quartile, firms with more than 10-years have a median productivity 10 percentage points higher than firms with less than 3-years. In countries with a recovery rate in the bottom quartile this difference in productivity between old and young firms is of only 1.5 percentage points. Quantitative simulations of a calibrated model economy show that this increase in firm turnover can have a large impact on aggregate income given the skewed

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1Klenow and Rodriguez-Claire 1997; Prescott 1998; Hall and Jones 1999
3Recovery rate is a particular measure of the quality of a country’s financial development. It is measured as the present value recouped by creditors, in cents, for every dollar lent to a firm that becomes insolvent. It is highly correlated with other traditional measures of financial development such as the ratio of private debt to GDP or the ratio of liabilities of the financial system to GDP.
4Following Jovanovic (1982) I assume that younger firms have higher uncertainty. Later I show that this assumption is supported empirically.
5The median recovery rates in the top and in the bottom quartiles are 0.85 cents on the dollar and 0.33 cents respectively.
6All these results are robust when controlling for differences in size, sector and country characteristics.
nature of the productivity distribution. Improving the recovery rate from the bottom quartile to the top one increases the aggregate income per worker by 43 percentage points. The quantitative nature of the model allows me to run some counterfactual experiments on the consequences of varying the punishment on default. I find that the optimal punishment, measured as the number of periods of exclusion to the credit markets, is monotonically decreasing in the recovery rate. Finally, I test empirically a series of novel predictions generated by the model, on firm growth and leverage dynamics, and show that these predictions are supported by the data and quantitatively important.

More specifically, I analyze an economy with default risk, where the recovery rate of the lender depends on the quality of debt enforcement. This quality has a direct impact on the interest rate since the risk-premium demanded depends on the fraction of debt recouped in case of firm default. The model economy is populated with three sets of agents: a representative consumer, financial intermediaries and entrepreneurs. The representative consumer supplies labor inelastically and invests his savings with financial intermediaries. These intermediaries are competitive, risk-neutral and lend funds to entrepreneurs at a risk-adjusted interest rate. Entrepreneurs can run one project at a time and use labor and capital as inputs. The productivity of the project has two components, a permanent and a transitory one. These components are not observed separately but as production occurs the entrepreneur is able to filter out the transitory component and update his expectations with increasing precision on the permanent component. Each period, after production is complete and expectations updated, the entrepreneur decides whether to continue the project or to exit. Since there is a punishment for default if borrowers choose to exit they must decide whether to default, and appropriate part of the debt, or to fully repay.

I solve the model using two different parameterizations. The first parameterization simplifies the model and uncovers testable analytical predictions. In the second parameterization I calibrate the model to simulate a benchmark economy by matching relevant moments of the data. This exercise allows for a quantitative assessment of the theory as well as the possibility to perform counterfactual policy experiments. I find that the recovery rate has sizable effects on per-capita income and on aggregate TFP.

In addition to the aforementioned results, this paper also provides an empirical contribution by documenting the empirical support on the two premises underlying the theory. The first premise is that entrepreneurs start their projects
highly dependent on external financing and the second is that the uncertainty on firm returns decreases with age. Using detailed cross-country firm-level data I show that the leverage ratios of entrant firms are relatively high, around 90%, across all countries in the sample and they decrease with age. This cross-country pattern of indebtedness suggests that external funding is crucial for entrant. The second premise, regarding the decrease of uncertainty, follows Jovanovic’s (1982) intuition that firms have a persistent unobserved component on productivity, which they learn as production takes place. The panel nature of the data, allows me to test this hypothesis by decomposing variation of firm returns, into a predictable and into an unpredictable component. Regardless of the measure of risk, I find that younger firms exhibit systematically higher idiosyncratic risk than their older counterparts. Finally, the model provides novel analytical predictions on growth and leverage dynamics. Regarding growth the model predicts that in countries with low recovery rate firms start smaller and grow faster. The reason is that the higher risk-premium reduces the optimal amount of debt and investment. This higher cost induces firms to delay the distribution of dividends and reinvest the retained earnings. This organic investment increases growth especially for young firms. From the empirical exercises we see that young firms, with less than 3 years old, in a country with a recovery rate similar to that of Bulgaria (0.33 cents) have an average growth rate 20 percentage points higher than a young firm in the United Kingdom (0.85 cents). This difference is reduced to 4 percentage points when we analyze firms with more than 10 years of age. Additionally, the model also predicts that deleverage is faster in countries with higher recovery rate. The reason is related to the aforementioned larger scale. In countries where the risk-premium is lower firms start at a larger scale and obtain higher profits. These larger profits allow firms to repay their debt and achieve the optimal long-term leverage relatively faster. I find that a decrease in recovery rate from the one in the U.K. to the one in Bulgaria leads to a 4 percentage points difference in leverage rates between firms with 1 and 10 years of age.

**Related Literature** - This paper contributes to a large literature relating financial frictions and entrepreneurship with economic development. The importance of financial institutions in promoting growth had long been defended by Goldsmith (1969), McKinnon (1973) or Shaw (1973). King and Levine (1993)

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7 Leverage is measured as the ratio of total liabilities to total assets.
8 The methodology used follows Castro, Clementi and Lee (2009).
built on Goldsmith’s work and documented that aggregate measures of credit
and financial development were closely correlated with output per capita. The
issue of causality was addressed Levine, Loyaza and Beck (LLB - 2000) and
using measures of legal origin as instruments they indicate that there is strong
connection between the exogenous component of financial intermediary develop-
ment and economic growth. Their results indicate an economically large impact
of financial development on growth.

The theoretical contributions relating financial and economic development
include Aghion and Bolton (1997), Piketty (1997), Amaral and Quintin (2007),
and Greenwood, Sanchez and Wang (2010). Amaral and Quentin present an
occupational choice model where the financial frictions are generated by differ-
ces in the degree of contract enforcement. They show that in economies with
poor contract enforcement there is more self-financing, production on small scale
and more unproductive establishments need to be operated for labor markets to
clear. Finally, Greenwood, Sanchez and Wang (2010) focus on the role of finan-
cial intermediaries in a scenario of costly verification. With decreasing returns
in information production more productive firms will end-up underfunded while
less productive ones will be overfunded. As the efficiency of the financial sector
rises the interest-rate spread and cost of borrowing decline and there is capital
deepening in the economy. The results of their calibrated model are that the
development of the financial sector accounted for 30% of the U.S. growth.

A similar strand of the literature also studies the relation between financial
and economic development but emphasize its cross-industry effects. It includes
work by Erosa and Hidalgo-Cabrillana (2008), Castro, Clementi and MacDon-
ald (2009) and Buera, Shin and Kaboski (2010). Erosa and Hidalgo-Cabrillana
analyze how the ability to enforce contracts affects the resource allocation and
relative efficiency across sectors. In a scenario where firms need external funds
to finance an industry-dependent fixed cost, and where they cannot credibly sig-
nal the quality of their project, they are financed only up to a fraction of their
net worth. Hence, countries with low financial development are characterized by
large cross-industry productivity differentials, and low aggregate productivity.
Castro et al show that the investment sector is inherently riskier than the con-
sumption sector and that it commands a risk premium from borrowers. This
increase in the cost of capital decreases the relative number of entrepreneurs
in the investment sector reducing overall productivity. An implication of their
model is that, as supported by the data, the correlation between investment
rate and GDP is weaker when measure at domestic versus international prices.
Buera et al defend that financial development affects income level by distorting the occupational choice. They argue that poor countries are unproductive in producing tradable goods because these have a larger optimal scale and therefore larger financial needs, rendering them more vulnerable to financial frictions. Therefore, when financial frictions are present the selection of entrepreneurs into the large-scale sector is based more on the individuals’ wealth and less on their entrepreneurial talent.

This paper is also related and complementary to the literature studying the implications of financial frictions on firm dynamics such as growth, leverage, entry and exit. Such works include, Hopenhayn (1992), Cooley and Quadrini (2001) and Arellano, Bai and Zhang (2010). Arellano et al analyze the impact of financial development on the firm policies such as leverage and growth. They document that in less financial developed economies, small firms grow faster and have lower leverage ratios than large firms, and show that financial restrictions can account for the majority of the difference in growth rates across countries. Their main mechanism is that in countries with worse financial institutions firms grow faster to decrease their financing costs. As they increase their size, and as the probability of default decreases, they increase their leverage to benefit from the lower financing costs.

The rest of the paper is organized as follows. Section 2 describes the firm-level dataset and documents the facts around which the model will be build. Section 3 introduces and characterizes the model, which is solved using two parameterizations. The first allowing for analytical solutions while the second calibrates it to match several moments of the data, providing a quantitative assessment of the model. Section 4 tests empirically the main predictions of the model. Section 5 concludes.

2 Empirical Facts

In this section I describe in detail the two main data sources as well as several summary statistics of the relevant variables. The first dataset, provided by the Doing Business division within the World Bank, has data at a country level and measures different outcomes of the insolvency process. Namely, the recovery rate recouped by creditors, the time to resolve the insolvency process, along with the sum of all legal costs involved. The second dataset, provided by the Bureau

\textsuperscript{9}http://www.doingbusiness.org/ExploreTopics/EnforcingContracts/
Van Dijk, contains information on firms in about 40 European countries. This dataset is valuable as it provides detailed financial information in a panel format on firms across the different European countries, with the sample of firms being representative of the universe of firms within each country.

2.1 Debt Enforcement

This paper links the costs of the insolvency process to the quality of debt enforcement. The information on the outcomes of the bankruptcy procedures, come from Djankov et al (2008). They present the same case study of an insolvent firm to insolvency practitioners in 88 countries. The case, developed jointly with the Committee on Bankruptcy of the International Bar Association, is representative of the insolvency of a midsized firm. The firm has a given number of employees, capital and ownership structure whose value as a going concern exceeds its value if sold piecemeal. The case is identical across countries, except that the economic values are all normalized by the country’s per capita income. Using several outcomes of the insolvency process, such as legal costs, nominal interest rate and length of the procedure, they compute the recovery rate of creditors. This recovery rate is an indicator that summarizes the efficiency of the bankruptcy proceedings. It is measured as the present value, net of all costs, recouped by the creditors of a defaulting firm. More concretely, the recovery rate $R$ of a representative firm in country $j$ as

$$ R_j = \frac{100GC_j + 70 (1 - GC_j) - 12 (P - 1) - 100c_j}{(1 + r_j)^t_j} $$

where $t$ represents the time in years to recover the funds, $r$ is the nominal interest rate, $c$ is the cost to complete the insolvency procedure expressed as a percentage of the bankruptcy estate, $GC$ is a dummy variable that takes the value 1 if continuing operations is the going concern of the insolvency process, and takes the value 0 otherwise.

The results of recovery rate are present in the first column of Table 1 while the second column represents the years it takes to complete the insolvency process.\(^{10}\)

An important question is whether the recovery rate is also an indicator of the level of financial development. In earlier work, King and Levine (1993) propose measures of financial development such as Private and Depth. Private is

\(^{10}\)The results present in Table 1 are obtained using data for the years 2004 and 2005.
Table 1: Indicators of Financial Development

<table>
<thead>
<tr>
<th>Country</th>
<th>Recovery Rate</th>
<th>Years</th>
<th>Cost</th>
<th>Private</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nor</td>
<td>0.94</td>
<td>0.9</td>
<td>0.01</td>
<td>0.76</td>
<td>0.54</td>
</tr>
<tr>
<td>Fin</td>
<td>0.88</td>
<td>0.9</td>
<td>0.04</td>
<td>0.70</td>
<td>0.54</td>
</tr>
<tr>
<td>Ire</td>
<td>0.88</td>
<td>0.4</td>
<td>0.09</td>
<td>1.42</td>
<td>0.88</td>
</tr>
<tr>
<td>Ned</td>
<td>0.87</td>
<td>1.1</td>
<td>0.04</td>
<td>1.61</td>
<td>1.10</td>
</tr>
<tr>
<td>Bel</td>
<td>0.86</td>
<td>0.9</td>
<td>0.04</td>
<td>0.72</td>
<td>1.03</td>
</tr>
<tr>
<td>UK</td>
<td>0.86</td>
<td>1</td>
<td>0.06</td>
<td>1.52</td>
<td>1.22</td>
</tr>
<tr>
<td>Ice</td>
<td>0.82</td>
<td>1</td>
<td>0.04</td>
<td>1.97</td>
<td>0.61</td>
</tr>
<tr>
<td>Swe</td>
<td>0.81</td>
<td>2</td>
<td>0.09</td>
<td>1.04</td>
<td>0.47</td>
</tr>
<tr>
<td>Spn</td>
<td>0.77</td>
<td>1</td>
<td>0.15</td>
<td>1.30</td>
<td>1.00</td>
</tr>
<tr>
<td>Prt</td>
<td>0.73</td>
<td>2</td>
<td>0.09</td>
<td>1.40</td>
<td>0.96</td>
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<td>0.63</td>
<td>3.3</td>
<td>0.04</td>
<td>1.62</td>
<td>0.58</td>
</tr>
<tr>
<td>Ger</td>
<td>0.56</td>
<td>1.2</td>
<td>0.01</td>
<td>1.11</td>
<td>1.05</td>
</tr>
<tr>
<td>Fra</td>
<td>0.46</td>
<td>1.9</td>
<td>0.09</td>
<td>0.90</td>
<td>0.73</td>
</tr>
<tr>
<td>Gre</td>
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<td>2</td>
<td>0.09</td>
<td>0.71</td>
<td>0.83</td>
</tr>
<tr>
<td>Ita</td>
<td>0.43</td>
<td>1.2</td>
<td>0.18</td>
<td>0.86</td>
<td>0.59</td>
</tr>
<tr>
<td>Slk</td>
<td>0.40</td>
<td>4.8</td>
<td>0.18</td>
<td>0.31</td>
<td>0.57</td>
</tr>
<tr>
<td>Hun</td>
<td>0.39</td>
<td>2</td>
<td>0.15</td>
<td>0.48</td>
<td>0.47</td>
</tr>
<tr>
<td>Est</td>
<td>0.37</td>
<td>3</td>
<td>0.09</td>
<td>0.62</td>
<td>0.41</td>
</tr>
<tr>
<td>Lat</td>
<td>0.36</td>
<td>3</td>
<td>0.13</td>
<td>0.55</td>
<td>0.39</td>
</tr>
<tr>
<td>Lit</td>
<td>0.34</td>
<td>2</td>
<td>0.22</td>
<td>0.33</td>
<td>0.36</td>
</tr>
<tr>
<td>Bul</td>
<td>0.34</td>
<td>3.3</td>
<td>0.09</td>
<td>0.38</td>
<td>0.54</td>
</tr>
<tr>
<td>Cro</td>
<td>0.29</td>
<td>3.1</td>
<td>0.15</td>
<td>0.56</td>
<td>0.64</td>
</tr>
<tr>
<td>Pol</td>
<td>0.26</td>
<td>3</td>
<td>0.22</td>
<td>0.28</td>
<td>0.42</td>
</tr>
<tr>
<td>Rus</td>
<td>0.25</td>
<td>3.8</td>
<td>0.09</td>
<td>0.23</td>
<td>0.29</td>
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<tr>
<td>Srb</td>
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<td>2.7</td>
<td>0.23</td>
<td>0.23</td>
<td>0.22</td>
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<tr>
<td>Czh</td>
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<td>9.2</td>
<td>0.18</td>
<td>0.33</td>
<td>0.68</td>
</tr>
<tr>
<td>Ukr</td>
<td>0.08</td>
<td>2.9</td>
<td>0.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rom</td>
<td>0.07</td>
<td>4.6</td>
<td>0.09</td>
<td>0.17</td>
<td>0.30</td>
</tr>
</tbody>
</table>

\[ \text{Corr}(\text{Recovery, }i) = 1 -0.69 -0.66 0.75 0.59 \]
measured as the ratio of credit to domestic firms over GDP. The assumption underlying this measure is that the larger the credit to private firms the more engaged financial intermediaries are in researching those same firms, in providing risk-management services and in facilitating transactions, rather than simply funneling credit to public enterprises. *Depth* is an indicator of the size of financial intermediaries and it is measured as the ratio of the liquid liabilities of the financial system to GDP. The data on these variables is present in the last two columns of Table 1 and was collected by Beck, Demirguc-Kunt, Levine. These indicators of financial development are highly correlated with the recovery rate, as demonstrated on the last row of Table 1.

### 2.2 Firm-level Data

The cross-country firm level data for this work comes from Analyze Major Database from European Sources (Amadeus). Amadeus is a comprehensive, pan-European database provided by Bureau van Dijk. It is a highly useful database as it not only covers a large fraction of new and small firms across all industries but it is also representative of the universe of firms at national level.\(^\text{11}\) The database, started in 1997, collects standardized data received from 50 vendors across Europe, with the local source for the data generally the office of the Registrar of Companies. Amadeus presents standardized annual (for up to 10 years) on financial ratios, activities and ownership for approximately 5 million companies per year with coverage varying by country. The database includes firm-level accounting data in standardized financial format for balance sheets, income statements, and financial ratios. The accounts are transformed into a universal format to enhance comparison across countries, though the coverage of these items also varies across countries. I use period average exchange rates from the International Monetary Fund’s International Financial Statistics to convert all accounting data into U.S. dollars. In addition to financial information, the dataset also provides other firm-level information such as the age of the firm, ownership and legal status. Amadeus, assigns companies a three-digit NACE code, the European standard of industry classification, which can be used to classify firms and construct industry dummy variables. The NACE codes follow the NACE Revision 1 classification. For the empirical study and for the numerical exercises I use the financial information presented for the 2002 to 2006 years.

\(^{11}\)In the appendix I provide a comparison between the Amadeus sample and the Universe of firms present in the Eurostat. The Eurostat data, available at http://epp.eurostat.ec.europa.eu, uses the full national business registers as data sources.
I choose these consecutive years, as they are the ones with the most complete coverage. Given that not all firms present the necessary information for the analysis I need to impose a number of restrictions in order to clean the data.\footnote{A more detailed explanation on the the cleaning of the data is documented on the appendix.} I exclude firms that do not provide data on assets, liabilities, sales and year of incorporation, or that provide negative sales or assets. Furthermore, I exclude countries with less than 1000 firms.\footnote{I exclude from this analysis Austria, Belarus, Cyprus, Liechtenstein, Luxembourg, Macedonia, Moldova, Monaco and Switzerland.} These criteria leave us with 13 million observations in 29 countries: Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Malta, the Netherlands, Norway, Portugal, Romania, Russian Federation, Serbia, Slovakia, Spain, Sweden, Ukraine and the United Kingdom. In the appendix, and following Arellano \textit{et al}, I show that the data for these 29 countries is representative of the universe of firms, by comparing it with data reported by the European Commission.\footnote{The data of the European Commission is provided by the several national offices of business registrars.} Small firms are slightly underrepresented in Amadeus and its fraction varies across countries, but this variation is not correlated neither with income level nor with financial development.

The main focus of this paper is on the effect that financial development has on firm dynamics. Therefore, and for exposition purposes I divided the firms within each country into five age-bins, with the amplitude of these bins being such that distribution of firms across each group is relatively equitave. In Table 2, I present the total number of firms per country along with the distribution of firms per age cohort, ordered by the quality of the recovery rate.

In Table 3, I present the median leverage and real asset growth for different age cohorts. Leverage is measured as the ratio of the total debt to total assets, whereas the asset growth is deflated by the CPI.\footnote{I define total debt as the sum of total liabilities, current and non-current. Current liabilities include all loans as well as all short-term loans from suppliers. Non-current liabilities includes long-term debt as well as other non-current liabilities such as provisions.} From this table it is clear that younger firms are more leveraged than their older counterparts irrespective of the recovery rate. The median leverage of the youngest and oldest cohort is 81 and 57 percent respectively and in \textit{all} countries in the sample firms delever-
<table>
<thead>
<tr>
<th>Country</th>
<th>Recovery Rate</th>
<th>No. Firms</th>
<th>Share of Firms</th>
<th>Age-Cohorts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;4</td>
<td>4-7</td>
</tr>
<tr>
<td>Nor</td>
<td>0.944</td>
<td>432,793</td>
<td>0.22</td>
<td>0.25</td>
</tr>
<tr>
<td>Fin</td>
<td>0.883</td>
<td>216,773</td>
<td>0.12</td>
<td>0.18</td>
</tr>
<tr>
<td>Ire</td>
<td>0.877</td>
<td>38,204</td>
<td>0.25</td>
<td>0.29</td>
</tr>
<tr>
<td>Ned</td>
<td>0.874</td>
<td>45,787</td>
<td>0.10</td>
<td>0.14</td>
</tr>
<tr>
<td>Bel</td>
<td>0.86</td>
<td>974,593</td>
<td>0.18</td>
<td>0.20</td>
</tr>
<tr>
<td>UK</td>
<td>0.856</td>
<td>1,139,416</td>
<td>0.34</td>
<td>0.23</td>
</tr>
<tr>
<td>Ice</td>
<td>0.817</td>
<td>39,271</td>
<td>0.36</td>
<td>0.27</td>
</tr>
<tr>
<td>Swe</td>
<td>0.81</td>
<td>565,565</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Spn</td>
<td>0.774</td>
<td>1,807,117</td>
<td>0.22</td>
<td>0.26</td>
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<td>173,222</td>
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<td>0.28</td>
</tr>
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<td>Ger</td>
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<td>148,490</td>
<td>0.15</td>
<td>0.19</td>
</tr>
<tr>
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<td>2,436,583</td>
<td>0.23</td>
<td>0.21</td>
</tr>
<tr>
<td>Gre</td>
<td>0.445</td>
<td>71,390</td>
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<td>0.22</td>
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<td>0.427</td>
<td>1,209,776</td>
<td>0.21</td>
<td>0.22</td>
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<td>Slk</td>
<td>0.398</td>
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<td>0.16</td>
<td>0.31</td>
</tr>
<tr>
<td>Hun</td>
<td>0.388</td>
<td>350,581</td>
<td>0.33</td>
<td>0.25</td>
</tr>
<tr>
<td>Est</td>
<td>0.366</td>
<td>139,259</td>
<td>0.34</td>
<td>0.31</td>
</tr>
<tr>
<td>Lat</td>
<td>0.357</td>
<td>13,298</td>
<td>0.17</td>
<td>0.29</td>
</tr>
<tr>
<td>Lit</td>
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<td>15,998</td>
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</tr>
<tr>
<td>Bul</td>
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<td>15,475</td>
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</tr>
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<td>62,885</td>
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<td>377,692</td>
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</tr>
<tr>
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<td>49,513</td>
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</tr>
<tr>
<td>Czh</td>
<td>0.154</td>
<td>158,346</td>
<td>0.20</td>
<td>0.31</td>
</tr>
<tr>
<td>Ukr</td>
<td>0.081</td>
<td>39,259</td>
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<td>0.37</td>
</tr>
<tr>
<td>Rom</td>
<td>0.069</td>
<td>774,217</td>
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</tr>
<tr>
<td>Total</td>
<td>0.52</td>
<td>11,543,684</td>
<td>0.21</td>
<td>0.24</td>
</tr>
</tbody>
</table>
age with age. Similarly, I point out the large levels of leverage present in the youngest cohort. In 22 out of the 27 countries in the data, the mean leverage in this cohort is larger than 75 percent, with this number dropping to 2 for the oldest cohort. Regarding asset growth, there is also a pattern of larger growth for younger firms. Furthermore, this pattern appears to be stronger in countries with lower financial development. For instance the mean growth (CPI-adjusted) in the youngest age-bin in Bulgaria, Croatia and Lithuania is 70, 58 and 63 percent whereas it is only 19, 21 and 31 percent in Belgium, Denmark and Finland respectively.

2.3 Age and Risk

In this section I document an empirical fact around which I build the model economy. It regards the decrease in idiosyncratic risk that occurs with age. This fact was first documented in Evans (1987) and he showed that the variability of firm growth decreases with age. This is broadly consistent with predictions of Jovanovic’s (1982) theory of firm growth in which entrepreneurs learn the quality of their project with time. To formally account for this fact, using the AMADEUS database, I follow a two-step procedure. In the first step I estimate for each country and for each age group\(^\text{16}\)

\[
\log z_{t,i} = \alpha_\tau + \delta_{jt} + \rho_\tau \log z_{t-1,i} + \varepsilon_{i,t}
\]  

(1)

where the dependent variable is the log of productivity \(\log z_{t,i}\) of firm \(i\) at time \(t\).\(^{17}\) The dummy variable \(\alpha_\tau\) is specific to the age-bin and allows for different average productivities whereas the dummy variable \(\delta_{jt}\) is sector-year specific and accounts for all unobserved sector heterogeneity present in a given year. These dummies offer a flexible way to control for variation in productivity induced by a variety of sectoral factors. Among which are weather shocks and business cycle

\(^{16}\)The objective of this exercise is to verify whether younger firms have higher variance on productivity. To obtain cleaner predictions, I estimate the regression for each country separately and allow for different persistence coefficient for the different age-bins.

\(^{17}\)I assume that firms have a sales production that depends on their assets and labor. Their production function is of the form

\[
y_{i,t} = z_{i,t} k_{i,t}^{\alpha_j (1-\alpha_j)}
\]

where \(\alpha_j\) is sector expenditure share on capital. Therefore, the productivity of the firm is calculated as

\[
z_{i,t} = \frac{y_{i,t}}{k_{i,t}^{\alpha_j (1-\alpha_j)}}
\]
<table>
<thead>
<tr>
<th>Ctry</th>
<th>Age-Cohorts</th>
<th>Sales Growth</th>
<th>Leverage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;4</td>
<td>[4,7]</td>
<td>[8,12]</td>
</tr>
<tr>
<td>Nor</td>
<td>0.21</td>
<td>0.12</td>
<td>0.09</td>
</tr>
<tr>
<td>Fin</td>
<td>0.31</td>
<td>0.18</td>
<td>0.14</td>
</tr>
<tr>
<td>Ire</td>
<td>0.45</td>
<td>0.18</td>
<td>0.13</td>
</tr>
<tr>
<td>Ned</td>
<td>0.27</td>
<td>0.14</td>
<td>0.10</td>
</tr>
<tr>
<td>Bel</td>
<td>0.19</td>
<td>0.12</td>
<td>0.09</td>
</tr>
<tr>
<td>UK</td>
<td>0.39</td>
<td>0.17</td>
<td>0.11</td>
</tr>
<tr>
<td>Ice</td>
<td>0.29</td>
<td>0.24</td>
<td>0.17</td>
</tr>
<tr>
<td>Swe</td>
<td>0.30</td>
<td>0.17</td>
<td>0.12</td>
</tr>
<tr>
<td>Spn</td>
<td>0.37</td>
<td>0.15</td>
<td>0.08</td>
</tr>
<tr>
<td>PRT</td>
<td>0.23</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>Den</td>
<td>0.21</td>
<td>0.13</td>
<td>0.07</td>
</tr>
<tr>
<td>GER</td>
<td>0.34</td>
<td>0.17</td>
<td>0.09</td>
</tr>
<tr>
<td>Fra</td>
<td>0.24</td>
<td>0.10</td>
<td>0.06</td>
</tr>
<tr>
<td>Gre</td>
<td>0.33</td>
<td>0.16</td>
<td>0.09</td>
</tr>
<tr>
<td>Ita</td>
<td>0.22</td>
<td>0.09</td>
<td>0.04</td>
</tr>
<tr>
<td>Slo</td>
<td>0.39</td>
<td>0.19</td>
<td>0.11</td>
</tr>
<tr>
<td>Hun</td>
<td>0.37</td>
<td>0.20</td>
<td>0.12</td>
</tr>
<tr>
<td>Est</td>
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</tr>
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<td>Lit</td>
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<td>Bul</td>
<td>0.70</td>
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</tr>
<tr>
<td>Cro</td>
<td>0.58</td>
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<td>0.06</td>
</tr>
<tr>
<td>Pol</td>
<td>0.29</td>
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<td>0.10</td>
</tr>
<tr>
<td>Rus</td>
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<td>0.17</td>
</tr>
<tr>
<td>Srb</td>
<td>0.71</td>
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<td>0.28</td>
</tr>
<tr>
<td>Czh</td>
<td>0.45</td>
<td>0.21</td>
<td>0.14</td>
</tr>
<tr>
<td>Ukr</td>
<td>0.68</td>
<td>0.23</td>
<td>0.11</td>
</tr>
<tr>
<td>Rom</td>
<td>0.41</td>
<td>0.23</td>
<td>0.18</td>
</tr>
</tbody>
</table>
fluctuations which tend to have different impact across sectors. The objective
of this estimation is to obtain the residuals $\hat{\varepsilon}_{i,t}$. Using these squared residuals
allows me to obtain the variance of the unpredicted component of each age-bin.
Results are present in Table 4.

Table 4: Firm Age and Risk

3 Model

In this section I present a general equilibrium model to analyze the impact of
debt enforcement on firm dynamics and on aggregate outcomes such as income
per worker and overall productivity. In particular, I use the recovery rate of
creditors as a measure of the quality of debt enforcement.\footnote{Recovery rate is the amount recouped by a creditor of an insolvent firm for each dollar of outstanding credit.}

An immediate result of the model is that the risk-premium on debt decreases with the recovery rate, particularly for young firms.\footnote{Young firms have higher uncertainty and therefore a larger risk-premium.} This decrease in the risk-premium, increases the outside option of starting a new firm leading entrepreneurs with worse projects to drop them and start anew. I show that this selection effect increases average productivity and has an important impact on aggregate income. For exposition purposes, and leading up the quantitative analysis, I present an example of the model with a parameterization that allows for closed form solutions, uncovering novel and testable predictions. Afterwards, I provide the quantitative results of a model parameterized to match several relevant moments of a benchmark economy. The quantitative nature of this calibration allows me not only to evaluate the impact of debt enforcement on firm selection and aggregate productivity, but also to perform counterfactual experiments. In particular, I analyze the optimal punishment for default and I show that this optimal punishment is decreasing in the recovery rate.\footnote{Punishment is measured as the expected number of periods of exclusion from credit markets after default.} \footnote{The length of the punishment has two opposing effects. On the one hand, a harsher punishment decreases the incentive for default, diminishing its probability and consequently the risk-premium on debt. On the other hand, longer exclusions reduce optimal leverage and growth as entrepreneurs attempt to reduce the default probability. Furthermore, a higher punishment on default induces leveraged firms with relative low quality to stay in the market until they are able to pay out their debt.}
3.1 Outline

The outline of the model is as follows: The economy is populated by a representative consumer, by financial intermediaries and by entrepreneurs. The representative consumer supplies a fixed amount of labor at a competitive wage and deposits his savings with financial intermediaries at a risk-free rate. Financial intermediaries are competitive, borrow their funds from the representative consumer and lend them to entrepreneurs at a risk-adjusted interest rate. Finally, there is a fixed mass risk-neutral entrepreneurs who can only run one firm at a time and have in management their only possible occupation. The productivity of a firm has a stochastic component whose variance, as mentioned above, is decreasing with age. Each period, after production is complete and before the transitory shock hits the firm, the manager decides whether to continue the project or to quit it and start a new one. In the latter scenario the manager must decide whether to repay any outstanding debt or to default partially on it. In case of default the manager is penalized with a temporary exclusion from credit markets. This possibility of default induces financial intermediaries to demand a risk-premium which is dependent on the quality of debt enforcement of the economy, on the size of the firm, on its outstanding debt, on its productivity and on its age.

**Representative Consumer** - The economy is populated by an infinitely lived representative consumer with mass $L$ and a discount rate $\beta_c$. He supplies labor inelastically for a wage $w$ and deposits his savings $K^c$ with a financial intermediary for a risk-free interest rate $r_f$. Each period, the consumer must decide how much to consume $c$ and how much to invest $i^c$. Formally, the problem of the representative consumer is

$$\max_{t=0}^{\infty} \sum \beta^t U(c_t)$$

s.t. $c_t + i_t^c = wL + r_f K_t^c$

$$K_{t+1}^c = (1 - \delta) K_t^c + i_t^c$$

From this problem we know that the representative consumer will save up to the point where his return on savings is equal to his discount rate. Therefore
in equilibrium the gross deposit rate $R_f$ is\(^\text{22}\)

\[ R_f = 1 + r_f = \frac{1}{\beta c} \]

**Financial Intermediaries** - The industry of financial intermediation is competitive as its members have free entry and exit. Financial intermediaries, are risk-neutral, collect savings from consumers at rate $R_f$ and lend them to entrepreneurs at a risk-adjusted rate $R_i$. This spread is due to the possibility of default. In this eventuality, the financial intermediary only recovers part of his credit, with the magnitude of this recovery rate $\xi$ depending on the quality of debt enforcement. More concretely, in the event of default the lender receives

\[ \xi \min \{ y_i - w_i, B_i \} \]

where $y_i - w_i$ represents the operational profits, $B_i$ the outstanding credit of firm $i$, and $\xi$ the recovery rate of the economy. This implies that in case of default the returns of the lender are

\[ \xi \min \left\{ \frac{y_i - w_i}{B_i}, R_i \right\} \]

The free-entry condition implies that the intermediation profits are zero leading us to the following condition

\[ R_f = (1 - \pi_i) R_i + \xi \int_{\frac{y_i - w_i}{B_i}}^{\tilde{z}} \min \left\{ \frac{y_i - w_i}{B_i}, R_i \right\} f(z)dz \]

(2)

where $\pi_i$ represents the exit probability of firm $i$, $z$ represents the productivity of the firm and $\tilde{z}$ the productivity below which the firm defaults. Therefore, the risk adjusted interest rate is

\[ R_i = \frac{R_f - \xi \int_{\frac{y_i - w_i}{B_i}}^{\tilde{z}} \min \left\{ \frac{y_i - w_i}{B_i}, R_i \right\} f(z)dz}{1 - \pi_i} \]

(3)

To provide some intuition to the expression above, assume that $\min \left\{ \frac{y_i - w_i}{B_i}, R_i \right\} = \]
In this case, condition 2 becomes

\[ R^f = (1 - \pi_i) R_i + \pi_i \xi R_i \]

implying that interest rate is

\[ R_i = \frac{R^f}{1 - \pi_i (1 - \xi)} \]

where is clear that interest rate is positively related with the probability of default, and negatively related with the recovery rate.

**Entrepreneurs** - Entrepreneurs have a mass 1 and maximize the present value of dividends at a discount rate \( \beta_e \). Each period, an equal number \( \phi \) of the entrepreneurs is born and dies. Projects have neither an entry nor an exit cost but managers can only run one firm at a time, which implies that if they decide to start a new project they must close their previous one. The productivity of the project is specific to the firm and has both a persistent and a transitory term. The main premise of the model regards the change in the variability of idiosyncratic risk with age. As documented in section 2, the variance in the returns of the firms decreases with age. I model this stylized fact with the variance of transitory component being decreasing with age. More concretely, the productivity process of a firm \( i \) with age \( \tau \) is

\[
\ln z_{i,t} = g(z_{i,t-1}) + \ln \varepsilon_{i,\tau,t} \\
\ln \varepsilon_{i,\tau} \sim i.i.d. (0, \sigma^2_{\tau}) \\
\sigma^2_{\tau} \geq \sigma^2_{\tau+1}, \forall \tau \geq 1
\]

where the variance of the transitory shock \( \sigma^2_{\tau} \) decreases with age.

Firms use capital and labor as inputs with their sales being

\[ y_{i,t} = z_{i,t} k_{i,t}^{\alpha} l_{i,t}^{\gamma} \]

\[ 0 \leq \alpha, \gamma, \alpha + \gamma \leq 1 \]

where \( z_{i,t}, k_{i,t} \) and \( l_{i,t} \) represent revenue productivity, capital and labor of firm \( i \) at time \( t \). Production \( y \) can be used either as consumption \( c \) or as investment \( i \). The capital accumulated by the firm depreciates at the rate \( \delta \), and is accumulated through periodical investments \( i \) which are made before the shock hits
the firm such that

\[ k_{i,t+1} = (1 - \delta) k_{i,t} + i_{i,t}, \quad i_{i,t} \geq 0 \]  

These investments are irreversible in the sense that the stock of capital is firm specific, and with no value for other projects.

After current productivity is known and production is complete, managers decide whether to continue their project or start a new independent firm. If the entrepreneur continues the project he must decide how much to invest and how much to borrow with the remaining funds being distributed as dividends \( d \) such that

\[ d_{i,t} + i_{i,t} = y_{i,t} - w l_{i,t} - B_{i,t-1} + \frac{B_{i,t}}{R_{i,t}} \geq 0 \]  

where the left-hand side represents the use of funds and the right-hand side their origins. In the event of firm exit, entrepreneurs decide whether to fully repay their outstanding debt, or to default and appropriate a fraction of it. If default occurs, entrepreneurs face a temporary exclusion from credit markets. This exclusion is measured as the probability \( p \) of reaccessing the market once default has occurred.\(^{23}\)

The timing of this model economy is as follows: At the beginning of each period an equal number of entrepreneurs is born and dies. Newborn entrepreneurs have no private endowment and require credit to finance their initial investments. Given their capital, debt, productivity, age and consequent set of interest rates, entrepreneurs make their investment and financing decisions. After these decisions are complete, firms are hit with an idiosyncratic shock. Given the idiosyncratic shock the entrepreneur hires labor and once production is complete he decides whether to continue with his firm or to exit the market and start a new project. If the entrepreneur decides to continue his firm then his expected value is

\[
V_{i,t}(K, B, z, \tau) = E_{t-1} \max \left\{ V^c, V^{nodef}, V^{def} \right\} \\
s.t. 6, 7
\]

\[ V^c = E_{t-1} V_{i,t}(0, 0, z, 0) \]

where \( V^c \) represents the value of continuing production while \( V^{nodef} \) and \( V^{def} \) represent the value of closing the firm with repayment and with default, respec-

\(^{23}\)This probability of reaccessing the market \( p \) can also be interpreted as the average number of periods \( P \) for which the defaulter is excluded from the market where \( P = \frac{1}{p} \).
tively. The outside option $V^o$ represents the value of an entrant firm. The value of continuing production $V^c$ is

$$V^c = y_{i,t} - w l_{i,t} - B_{i,t-1} + \frac{B_{i,t}}{R_{i,t}} - i_t + \beta_c (1 - \phi) V_{i,t+1}$$

Conversely, if the entrepreneur closes the firm and decides to repay his outstanding debt then his value is

$$V_{i,t}^{nodef} = y_{i,t} - w l_{i,t} - B_{i,t-1} + \beta_c (1 - \phi) V^o$$

where $V^o$ represents the value of a new firm. Finally, if manager decides to default, his value is

$$V_{i,t}^{def} = \max \{(1 - \xi) (y - w l_t), y - w l_t - \xi B_t\} + \frac{\beta_c (1 - \phi) \rho}{1 - \beta_c (1 - \phi) (1 - p)} V^o$$

**Market Clearing**

In this section we present the conditions that clear the capital, labor and consumption markets. The supply of labor of the representative consumer must equal the labor demand such that

$$L = \int_0^1 l_{i,t} \, dz$$

Furthermore, the market clearing condition for the capital market is

$$K^c = \int_0^1 \frac{B_{i,t}}{R_{i,t}} \, dz$$

where $K^c$ represents the capital supply of the representative consumer while $\int_0^1 \frac{B_{i,t}}{R_{i,t}} \, dz$ represents the aggregate capital demand of entrepreneurs. Finally, the market for the consumption good clears when its demand is equal to the aggregate supply

$$c + i_c + \int_0^1 (d_i + i_i) \, \partial i = \int_0^1 y_i \, \partial i$$

### 3.2 Example

To provide some intuition on the basic mechanisms of the model I parameterize it so that analytical results can be easily obtained. The parameterization, described in the table below, is such that: i) All uncertainty is resolved by the
second period. ii) Permanent component of productivity is drawn from an uniform distribution, with \( \bar{z} > R^c \). iii) Firms use capital as the only input, have constant returns to scale and an exogenous cap on size. iv) The rate of discount is the same for entrepreneurs and lenders. v) There is complete depreciation of capital. vi) There is no market exclusion for a defaulter.

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>( z_i = \varepsilon_i )</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>( \varepsilon \sim U[\bar{z}, \bar{z}] )</td>
</tr>
<tr>
<td>Technology</td>
<td>( \alpha = 1 )</td>
</tr>
<tr>
<td>Cap on size</td>
<td>( k_t \leq \bar{k} )</td>
</tr>
<tr>
<td>Discount rate</td>
<td>( \beta_c = \beta_c )</td>
</tr>
<tr>
<td>Depreciation</td>
<td>( \delta = 1 )</td>
</tr>
<tr>
<td>No exclusion</td>
<td>( p = 1 )</td>
</tr>
</tbody>
</table>

This parameterization implies that labor has no role in the economy, allowing us to focus on the relation between entrepreneurs and financial intermediaries.

3.2.1 Share of Entrant Firms

To determine the stationary equilibrium of the economy I must calculate the share of entrant firms. This share depends on the number of firms that exit the market endogenously as well as on those that and are born and die exogenously. As all uncertainty is resolved by the second period, endogenous exit will only occur in the first period and if the productivity of the project \( \varepsilon \) is below a certain threshold \( \bar{z} \). In addition to the endogenous exit, firms die and exit exogenously with probability \( \phi \). In equilibrium the number of entrants \( \lambda \) is equal to the endogenous exit \( \lambda \frac{\bar{z} - \xi}{\bar{z} - \bar{z}} \) plus the exogenous one \( (1 - \lambda) \phi \), such that

\[
\lambda = \frac{\bar{z} - \xi}{\bar{z} - \bar{z}} + (1 - \lambda) \phi
\]

this implies that the fraction of entrant firms is

\[
\lambda = \frac{1}{1 + \frac{1}{\phi} \left( 1 - \frac{\bar{z} - \xi}{\bar{z} - \bar{z}} \right)}
\]

\(24\)The assumption that \( \bar{z} > R^c \) guarantees that the operational profits of the firm cover the outstanding debt (i.e. \( zk > B \forall z \)). Later, I show that in equilibrium it is verified that \( \bar{z} > R^c \).
which is positively dependent on both the birth rate \( \phi \) and on the productivity cutoff \( \overline{\varepsilon} \).

### 3.2.2 Firm Value and Productivity

In order to pin down the aggregate firm productivity we must obtain the entrant firm’s value along with the productivity cutoff. As endogenous exit only occurs at the end of the first period, and given that \( \varepsilon \) has an uniform distribution, the value of an entrant firm is

\[
V^o = E\left[\varepsilon^e \frac{B^e}{R^e} - (1 - \pi^e (1 - \xi)) B^e + \beta (1 - \phi) \left( \pi^e V^o + (1 - \pi^e) \left( \frac{(z^i - R^f) \overline{k}}{1 - \beta (1 - \phi)} \right) \right) \right] \tag{9}
\]

\[
\pi^e = \frac{\overline{\varepsilon} - \varepsilon}{\varepsilon - \overline{\varepsilon}}; \quad z^e = \frac{\varepsilon + \overline{\varepsilon}}{2}; \quad z^i = \frac{\varepsilon + z^e}{2} \tag{10}
\]

where \( \pi^e \) represents the probability of exit in the first period and \( z^e \) and \( z^i \) represent the average productivity of the entrant and incumbent cohorts respectively. The value of an entrant firm, in 9, reflects the expected profits \( \varepsilon^e \frac{B^e}{R^e} - B^e \) plus the maximum between the decision to default and start a new firm \( (1 - \xi) B^e + \beta (1 - \phi) V^o \) and the decision to continue the firm and receive \( (z^i - R^f) \overline{k} \) in perpetuity.

The entrepreneur decides to exit if the continuation value is lower than the exiting value. The productivity at which the entrepreneur is indifferent between exiting or continuing is such that

\[
(1 - \xi) B^e + \beta e (1 - \phi) V^o = \frac{(\overline{\varepsilon} - R^f) \overline{k}}{1 - \beta (1 - \phi)} \tag{11}
\]

and from this condition we can derive the productivity cutoff

\[
\overline{\varepsilon} = \frac{1 - \beta (1 - \phi)}{\overline{k}} (V^o + (1 - \xi) B^e) + R^f \tag{12}
\]

indicating that the productivity below which entrepreneurs decide to exit depends on both the value of starting a new firm and on the value of outstanding debt.

**Lemma 1** The value of an entrant firm \( V^o \) is increasing in the recovery rate.
Figure 1: Firm Age and Productivity

**Proof.** See section 7.1 in the appendix. ■

**Proposition 2** Incumbent firm cohorts are relatively more productive than entrant cohorts with this difference being increasing in the recovery rate.

**Proof.** See section 7.1 in the appendix. ■

**Lemma 3** The share of entrant firms, on the total number of firms, is increasing in the recovery rate.

**Proof.** Using the definition 8 and the proposition 4.1 we have the result. ■

**Lemma 4** Entrants are larger in countries with higher recovery rate.

**Proof.** See section 7.1 in the appendix. ■

**Proposition 5** Young firms grow faster in countries with lower recovery rate.

**Proof.** Using lemma 4 we know that entrants’ size is increasing in recovery rate, while the incumbents’ size is independent of recovery rate. Hence the result. ■

The intuition for the above result is as follows. From 3 we have that the interest rate is convex on the probability of default. This implies that the
reduction in the risk-premium, due to the elimination of uncertainty, is higher in countries with lower recovery rate. This higher reduction allows firms to invest relatively more in the subsequent periods. This result is graphed in Figure 2 where the relative growth across time of different firms across the economy are reflected.

Finally, we can also make some predictions for the dynamics on leverage.

Proposition 6  
Firms in countries with better recovery rate deleverage faster

Proof. See section 7.1 in the appendix. ■
This proposition is graphed in Figure 3. The intuition for the faster delever-
age is simple. First, notice that although initial leverage is independent of the level of the recovery rate firms start larger and with higher profits in countries with better recovery rate. Using the assumption that $\beta = \frac{1}{R_f}$, this implies that they pay their outstanding debt and achieve their long-run leverage faster.

3.2.3 Aggregate Production and Productivity
The main interest of this paper is in analyzing the impact that the recovery rate has on aggregate production and productivity. Aggregate production $Y$ is

$\text{Lev}^c = \frac{B_c^c}{K_c} = R^c = z^c + \frac{R_f}{2}$
measured as the production of all firms. Formally,

\[ Y = \lambda y^e + (1 - \lambda) y^i \]  
\[ y^e = \frac{\varepsilon + \pi B^e}{2 R^e} \]  
\[ y^i = \frac{\varepsilon + \pi K}{2} \]

where \( y^e \) and \( y^i \) represent the average production of entrant and incumbent firms. From the definitions of \( \lambda \) and \( Y \) in 8 and 13 we obtain the following result.

**Proposition 7** Aggregate production is increasing in recovery rate.

**Proof.** See section 7.1 in the appendix  ■

The above proposition resolves the trade-off between the number of entrants, their relative size and aggregate production. On the one hand in countries with better recovery rates the number of, the relatively small, entrant firms is higher, but on the other hand those entrants are also larger in those countries. Proposition 7 shows that this last effect is stronger and that aggregate production is increasing in recovery rate.

The model also allows us to make inferences regarding firm productivity. From it we can uncover the relation between recovery rate and the productivity
of the \emph{average} firm’s productivity

\[
z_{\text{avg}} = \lambda \frac{\bar{z} + \bar{e}}{2} + (1 - \lambda) \frac{\bar{e} + \bar{z}}{2}
\]

Using the definitions of $\lambda$ and $\bar{e}$ allows us to obtain the following relation

\textbf{Prediction} Countries with higher \emph{recovery rate} have higher average firm productivity.

\textbf{Proof.} See section 7.1 in the appendix \[\blacksquare]\]

The aggregate productivity of an economy is measured as the ratio of total production to total inputs used. Formally,

\[
z_{\text{prod}} = \frac{Y}{K}
\]

\[
Y = \lambda y^e + (1 - \lambda) y^i
\]

\[
K = \lambda k^e + (1 - \lambda) k^i
\]

where $Y$ is the overall production of the economy while $K$ represent all the inputs used. Using the above lemma on average productivity we establish the following relation

\textbf{Prediction} Countries with better \emph{recovery rate} have higher aggregate productivity.

\textbf{Proof.} See section 7.1 in the appendix \[\blacksquare]\]

In this section I have established the important results that income level and aggregate productivity are positively related with the quality of \emph{recovery rate}.

\section{3.3 Quantitative Results}

In this section I solve the model in numerical form calibrating it to jointly match relevant moments in the data of a benchmark economy.\textsuperscript{26} For this calibration exercise, and using the productivity distribution in 5, I assume that productivity follows a first-order idiosyncratic process of the type

\[
\ln z_{i,t} = (1 - \rho) \ln z + \rho \ln z_{i,t-1} + \ln \varepsilon_{i,t} \\
\ln \varepsilon_{i,t} \sim N\left(0, \sigma^2 \right)
\]

\textsuperscript{26}Section 7.2 in the Appendix provides details on the computational algorithm.
This particular process has the novelty that both the persistence coefficient $\rho_{\tau}$ and the variance of the idiosyncratic process $\sigma_{\tau}^2$ are age-dependent. Their values will be estimated using the data of the benchmark economy.

### 3.3.1 Calibration

Calibration is done so that the model economy matches key aspects of the United Kingdom, our benchmark economy. I specify values for the sixteen parameters: $(r_f, \alpha, \gamma, \delta, p, \phi, L, \beta_e)$ and $\left(\text{prtr}^{j'}_i, \rho_j, \sigma_j | j \in \{e, i, o\}\right)$. From these parameters the first four can be set to standard values in the literature. I let $r_f = 0.05$, $\alpha = 0.3$, $\gamma = 0.6$ and $\delta = 0.08$.\(^{27}\)

I am left with twelve parameteres that are more specific to my study. I assume that a young firm expects on average four years until it becomes an incumbent, while an incumbent expects on average eight years until it becomes old. Therefore, $\text{prtr}^{e'}_i = 0.25$ and $\text{prtr}^{i'}_i = 0.125$. Following this definition of the lifecycle of the firm, I estimate the parameters $\rho_j$ and $\sigma_j^2$ for each of the three states and using the data from UK firms. Their values can be found in Table 5. The relative number of workers to entrepreneurs $L$ is taken from the AMADEUS data for France and set to 21.\(^{28}\) Finally, $p$ is set to 0.5 following Dias (2010).\(^{29, 30}\)

The remaining parameters $\phi$ and $\beta_e$ are calibrated to match two relevant moments in the UK data: The share of entrant firms which is directly affected by $\phi$, and the long-run leverage which is impacted by $\beta_e$. Using the UK data for 2005, we have that 41% of the UK firms have less than five years of age, and

\(^{27}\)The risk-free rate being $r_f$ set to 5% which corresponds to the real interest rate for the UK in 2004. The decreasing returns parameter $\alpha + \gamma$ is chosen to be 0.90 following Atkeson and Kehoe (2005), and I choose $\frac{1}{\alpha + \gamma}$ to match an aggregate capital income share of 0.33.

\(^{28}\)Only 20 percent of the U.K. firms have data on employment, with small firms presenting the most missing data. Therefore, I use data on French firms, which comprise the most observations and do not seem to suffer from this bias. The French sample is comprised of 409,115 firms that employ 8,753,180 workers averaging 21 employees per firm. Overall in the AMADEUS database there are 31 employees per firm.

\(^{29}\)Dias (2010) studying a panel of portugese firms, finds that the period of exclusion from credit markets is on average of two years. Later I will present the results for the sensitivity analysis.

\(^{30}\)Several studies on exclusion from default Chatterjee et al. (2007), Arellano et al. (2010) follow Musto (1999). In this study, Musto analysis the impact that the \textit{flag} of personal default has on the credit rating and credit access in the United States, where credit agencies are allowed to \textit{flag} a personal default for up to ten years from the default episode. He shows that there is an important discontinuity in both the credit rating as well as in the credit limit from the 10th to the 11th year after the event. Nevertheless, it is also clear from the paper that private defaulters are not completely excluded from the markets during their \textit{flag} periods. In fact their credit limit during these periods is 40 percent, on average, from that in the \textit{no flag} periods.
that the leverage of old firms is on average 0.60.\footnote{Please refer to Tables 2 and ?? for more information on other relevant statistics.}

<table>
<thead>
<tr>
<th></th>
<th>Target Moment</th>
<th>UK Data</th>
<th>Model</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk-free rate</td>
<td>0.05</td>
<td>0.05</td>
<td></td>
<td>( r_f )</td>
</tr>
<tr>
<td>Probability of transition</td>
<td>0.25, 0.15</td>
<td>0.25, 0.15</td>
<td>( prtr^c_i, prtr^o_i )</td>
<td></td>
</tr>
<tr>
<td>Persistence</td>
<td>0.70, 0.85, 0.92</td>
<td>0.70, 0.85, 0.92</td>
<td>( \rho_e, \rho_i, \rho_o )</td>
<td></td>
</tr>
<tr>
<td>Variance shocks</td>
<td>0.12, 0.08, 0.05</td>
<td>0.12, 0.08, 0.05</td>
<td>( \sigma_e^2, \sigma_i^2, \sigma_o^2 )</td>
<td></td>
</tr>
<tr>
<td>Workers per entrepreneur</td>
<td>21</td>
<td>21</td>
<td>( T )</td>
<td></td>
</tr>
<tr>
<td>Share of entrant firms</td>
<td>0.41</td>
<td>0.39</td>
<td>( \phi = 0.06 )</td>
<td></td>
</tr>
<tr>
<td>Long-run leverage</td>
<td>0.60</td>
<td>0.39</td>
<td>( \beta_e = 0.9 )</td>
<td></td>
</tr>
</tbody>
</table>

### 3.3.2 Calibration Results

In this section I examine the calibration results. I compute and simulate an economy, under the British calibration with 10,000 firms for 500 periods. The last period of the simulation provides me with the long-term cross-section from which I obtain all the statistics. I divide the cross-section of firms between entrant, incumbents and old.\footnote{Firms start the project as entrants, and have a predetermined probability of transiting into incumbency. Once incumbents they have a certain probability of becoming old, which is an absorbing state.}

**Productivity Cutoff**

An important component of the model is the productivity below which firms decide to exit. In this section I analyze the productivity cutoff across firm age and across recovery rates. In the left panel of Figure 4 I graph the productivity cutoff of, a debtless firm, for different asset holdings and different ages. As expected, the cutoff is decreasing in the size of the firm. Furthermore, this productivity cutoff is increasing in the phase of the lifecycle of the firm. This is to say that older firms have higher productivity cutoff than their younger counterparts. The reason for this higher cutoff is related with the lower option value that the decrease in variance brings.

In the right panel of Figure 4, I compare the productivity cutoffs of an economy with a high recovery rate \( \xi = 0.85 \), with those of an economy with a low recovery rate \( \xi = 0.25 \).\footnote{I chose these two recovery rates as they represent the debt enforcement present in the United Kingdom and in Russia. The United Kingdom is the benchmark country, whereas Russia has a recovery rate placing it in the median of the lower quartile.} As expected, and due to the higher outside option,
the cutoffs are higher in economies with better recovery rate.

**Quality of Fit**

The results of the simulation are present in Table 6. It shows that the model is successful in matching the target moments: share of entrant firms and the leverage of old firms. Furthermore, the model is able to replicate several additional moments of the empirical distribution that were not targets in the calibration. Moments such as relative productivity, relative size, leverage, growth and the share of entrant firms.

As predicted by the selection mechanism, older firms in the data and in the model are on average 31 percent more productive than their younger counterparts. The model is also able to replicate the size patterns present in the data. Namely, that older firms are almost thirty times larger than entrant firms. Additionally, the model is able to match quantitatively the leverage patterns across

---

34 In the empirical results *entrant* firms have less than five years, *incumbent* firms are those with more than four years and less than thirteen, and *old* firms have more than twelve years.

35 The empirical moments are from the United Kingdom, our benchmark economy. The moments of model simulations, were obtained using the United Kingdom’s recovery rate of 0.85.

36 I calculated the empirical counterpart of the revenue productivity as

$$\text{TTFP}_i = \frac{Y_i}{K_i^{\alpha_j} L_i^{1-\alpha_j}}$$

where $Y_i$ represents the operating revenue of firm $i$, $K_i$ the assets of the firm, and $L_i$ the employees. The capital and labor shares are sector- specific.
age-cohorts.

<table>
<thead>
<tr>
<th>Table 6: Moments</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moments</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>entrants</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>incumbents</td>
<td>1.20</td>
<td>1.08</td>
</tr>
<tr>
<td>old</td>
<td>1.29</td>
<td>1.19</td>
</tr>
<tr>
<td><strong>Relative Size - Assets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>entrants</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>incumbents</td>
<td>3.8</td>
<td>6.2</td>
</tr>
<tr>
<td>old</td>
<td>27.2</td>
<td>27.6</td>
</tr>
<tr>
<td><strong>Leverage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>entrants</td>
<td>0.80</td>
<td>0.56</td>
</tr>
<tr>
<td>incumbents</td>
<td>0.69</td>
<td>0.60</td>
</tr>
<tr>
<td>old</td>
<td>0.60</td>
<td>0.51</td>
</tr>
<tr>
<td><strong>Share of Firms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>entrants</td>
<td>0.31</td>
<td>0.39</td>
</tr>
<tr>
<td>incumbents</td>
<td>0.37</td>
<td>0.35</td>
</tr>
<tr>
<td>old</td>
<td>0.32</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Employment per Firm</strong></td>
<td>21</td>
<td>21</td>
</tr>
</tbody>
</table>

**Cross-country variation**

In this section I check whether the various simulations of the model for different levels of recovery rates replicate the data. For each of the comparisons I will contrast the data from our benchmark economy, the United Kingdom, with that of Russia. I choose Russia, given that its recovery rate is in the median of the lowest quartile of my sample. In the left panel of Figure 5, I compare the empirical productivity per age-cohort of firms in the United Kingdom and in Russia. As predicted by the model, older firms are relatively more productive than younger firms in countries with better debt enforcement. More specifically, 10 years-old firms are 15 percent more productive relative to their entrant counterparts. In countries with worse debt enforcement, the

In Figure 6, I present the growth rates per age-cohort. In the left-panel, and as in the previous Figure, I present the data for the U.K. and Russia. As expected, growth rates are larger in country with worse debt enforcement although both converge to 0 with age. In the right panel I present the results of the two simulations where the only difference is on the recovery rate. The simulation designated "U.K." mimics the empirical recovery rate of 0.85 of the U.K. whereas the simulation "Russia" uses the Russian recovery rate of 0.25.

In Figure ??, I verify whether the remaining predictions of the example hold. In the first panel, I represented the average firm-size per age-cohort. As stated
Figure 5: Productivity of per Age - Data and Model

Figure 6: Growth per Age-Cohort.
in Lemma \(??\), firms start larger in countries with better recovery rates. In the second panel, I check that Proposition 4.3 holds. It states that firms grow faster in countries with worse debt enforcement. In the third panel I verify that Lemma 4.4 holds. It states that average entrant leverage is similar across levels of recovery rate, but that deleverage is faster in countries with better debt enforcement. Finally, in the last panel I confirm the prediction, stated in Proposition 7, that aggregate production is increasing in debt enforcement.

An important implication of the model is that the share of entrant firms is increasing in the level of the recovery rate.

I also show that the recovery rate has a positive substantial impact on the level of production per worker. In Figure 7, I plot both the simulated effect of the recovery rate along with data on both income per capita and TFP.\(^{37}\) The income and TFP data is relative to the United Kingdom benchmark. In my model, the variation in recovery rate can decrease the income per capita to 65 per cent of the UK level. Although this difference is far from replicating the large income discrepancy between the UK and the poorest countries in the sample, its magnitude is considerable given that I am only varying one factor.

Next, I try to disentangle the various forces behind the difference in income

\(^{37}\)The correlation between recovery rate and income per capita is 0.78 whereas the correlation between recovery rate and aggregate TFP is 0.72.
Figure 7: Recovery Rate, Income per Capita and TFP
per capita. The magnitude of the recovery rate affects the cost of debt. Additionally, the risk-premium may distort the optimal firm size, contributing to differences in the marginal product of capital across firms. Productive firms that are young and small may be capital constrained and take longer to achieve their optimal size. Furthermore, old and relatively unproductive firms may stay in market longer than optimal given that their relative lack of risk allows them to take advantage of lower interest rates.

Here I analyze quantitatively how the recovery rate affects aggregate productivity by distorting the allocation of capital.

**Policy**

In this section I analyze the optimal punishment, measured as the periods of exclusion from credit markets after default. For each level of recovery rate $\xi$ I calculate the optimal $p^*$ that maximizes production per worker. Results are in Figure.

A second exercise that I do is in calculating the difference in income per capita using the the optimal punishment $p^*$ calculate above.

### 3.4 Computational Algorithm

#### 3.4.1 Setup

The numerical problem has four state variables. Capital, debt, productivity and age. I discretize all state variables and compute the solution using value function iteration. A solution is found when a fixed point is found such that the value function does not vary, the probability of default does not change and the capital and labor supplied is equal to its demand.

#### 3.4.2 Productivity

Productivity has a lognormal distribution such that

$$\ln z_{i,t} = (1 - \rho) \ln z + \rho_i \ln z_{i,t-1} + \varepsilon_{i,\tau,t}$$

$$\varepsilon_{i,\tau} \sim N(0, \sigma_{\varepsilon,\tau}^2)$$

To discretize the productivity process $z$ I followed the approach in Tauchen (1986). Let $\tilde{z}$ denote the discrete-valued process that approximates the continuous process $z$, and let $\tilde{z}^1 < \tilde{z}^2 < \ldots < \tilde{z}^N$ denote the values that $\tilde{z}$ may take on.
I calculate the transition matrix \( p_{jk} = \Pr [\tilde{z}_t = z^k | \tilde{z}_{t-1} = z^j] \) as follows. Using \( w = z^k - z^{k-1} \) then for each \( j \) if \( k \) is between 2 and \( N - 1 \) set

\[
p_{jk} = \Pr \left[ \frac{z^k - w}{2} \leq (1 - \rho) \ln z + \rho_1 \ln z_{i,t-1} \leq \frac{z^k + w}{2} \right] = F \left( \frac{z^k - (1 - \rho) \ln z - \rho_1 \ln z_{i,t-1} + \frac{w}{2}}{\sigma_\varepsilon} \right) - F \left( \frac{z^k - (1 - \rho) \ln z - \rho_1 \ln z_{i,t-1} - \frac{w}{2}}{\sigma_\varepsilon} \right)
\]

otherwise

\[
p_{jl} = F \left( \frac{z^l - (1 - \rho) \ln z - \rho_1 \ln z_{i,t-1} + \frac{w}{2}}{\sigma_\varepsilon} \right)
\]

\[
p_{jN} = 1 - F \left( \frac{z^N - (1 - \rho) \ln z - \rho_1 \ln z_{i,t-1} - \frac{w}{2}}{\sigma_\varepsilon} \right)
\]

## 4 Testing Model Predictions

In this section, I test empirically the main predictions obtained in section 3.2.

### 4.1 Firm Selection

The first prediction of the model (proposition) posits that selection is stronger in countries with better debt enforcement.\(^{38}\) This implies that firm productivity should not only increase across age-cohorts, but it should increase more in countries with better financial institutions. To calculate the firm level productivity, I assume that firms have a technology of the type

\[
y_i = A_i k_i^{\alpha_i} l_i^{\beta_i}
\]

where \( y_i, k_i \) and \( l_i \) represent the sales, capital and labor used by firm \( i \) and the input shares \( \alpha \) and \( \beta \) are at the sector-\( j \) level.\(^{39}\) Although I have data on total sales, I do not observe neither physical production nor prices. As I cannot disentangle price \( P_i \) from physical production \( y_i \), I use revenue-productivity

---

\(^{38}\)Selection on productivity refers to the process in which entrepreneurs with low productivity projects exit the market. This process increases the average productivity of the remaining incumbents.\(^{39}\) I calculate the input shares at the 2-digit NACE level. These shares are calculated for French firms, which have the most comprehensive data, and the factor intensity is assumed to be equal across countries.
$TFP_i^R$ as a measure of productivity such that

$$
TFP_i^R = P_iA_i = Sales_i^{\frac{\alpha_1}{\alpha_2}}
$$

To test the first prediction I estimate

$$
\ln TFP_{c,a}^R = \alpha_0 + \alpha_1 \ln (age_{c,a}) + \alpha_2 \ln (age_{c,a}) \ln (RR_c) + \text{dummies} + \varepsilon_i
$$

where the dependent variable is the log of the firm productivity, as defined above, and the regressors are the log of firm age, the interaction of the log firm age with log Recovery Rate along with country and sectoral fixed-effects.\(^{40}\) The Age and the Recovery Rate regressors are transformed into logs given the non-linearities predicted by the model. Dummy represents country×sector×year fixed-effects. The country fixed-effects control for country characteristics such as institutional quality, accounting procedures and political system. Industry effects are at the NACE 2-digit level and control for industry characteristics such as factor intensity, competition structure and external financial dependence. Finally, year fixed-effects controls for business cycle fluctuations. Furthermore, the interaction between the fixed-effects allows us to capture all the idiosyncratic features of each sector for each year in a particular country such as the impact that a recession has across different sectors in each country.

I present the results of the estimation in the first column of Table 7. The regression has standard errors, which are in parentheses, which are robust to heteroskedasticity. As predicted by the model, both the age and the interaction coefficients are positive and significant at the 1% level. This implies that older firms are relatively more productive than younger firms with this difference increasing with the country’s Recovery Rate. The magnitude of the Age coefficient implies that the median firm in the 5-year cohort is 2.8 percentage points more productive than the median entrant firm. The interpretation of the interaction coefficient is analogous to a second derivative. To give a sense of its magnitude I compare the difference in the median productivity of 1-year-old and 5-year-old firms in Russia and the United Kingdom.\(^{41}\) The difference

\(^{40}\)I calculate the regression on logs as from equation XXX we have that the relation between average productivity and recovery rate is non-linear.

\(^{41}\)As referred above, I chose Russia and the United Kingdom for comparison purposes. The United Kingdom is my benchmark economy, whereas Russia is the median of the bottom quartile.
in the median productivity of firms in the 5-year cohort relative to the 1-year cohort is around 3 percentage points larger in United Kingdom. This difference understates, potentially by a great margin, the overall effect that selection has on aggregate productivity since the distribution of TFP is highly skewed.

An important caveat, regarding the data, concerns the fact that roughly half of the countries in the sample were under the Communist regime up until 1991. Therefore it is possible, if not probable, that the older firms in these countries have different productivities and firm dynamics simply due to this legacy. To control for this possibility, I conduct a robustness check for all predictions by restricting the maximum firm age in the sample to 15 years. In the second column of Table 7 I present the results for a censored sample of firms with less than 15 years. This robustness check does not alter nor the sign of the previous results nor their magnitude.

Another potential concern regards the way productivity is measured. Assets are measured using their accounting value which may be at historical values not reflecting their economic value. This may imply that the productivity for different cohort of assets may be measured differently. To attempt to control for this problem, I estimate the above equation using sales per employee as the measure of productivity. The coefficients are present in the third column of Table 7 and confirm the previous results.

**Robustness Checks**

In this section I perform additional checks on the robustness of the results. In the first test I split the sample in half with countries with recovery rate above and below the median. Then I run the regression 14 twice. Once for firms in countries with a recovery rate above median recovery rate, and once for firms

### Table 7: Recovery Rate and Firm Selection

<table>
<thead>
<tr>
<th></th>
<th>All Sample</th>
<th>&lt;15 Yrs.</th>
<th>Sales/Empl</th>
</tr>
</thead>
<tbody>
<tr>
<td>log((\text{Age}_i))</td>
<td>0.039</td>
<td>0.032</td>
<td>0.138</td>
</tr>
<tr>
<td></td>
<td>(0.007)**</td>
<td>(0.008)**</td>
<td>(0.007)**</td>
</tr>
<tr>
<td>log((\text{Age}_i) \times \log(\text{RR}_c))</td>
<td>0.028</td>
<td>0.018</td>
<td>0.069</td>
</tr>
<tr>
<td></td>
<td>(0.008)**</td>
<td>(0.009)**</td>
<td>(0.013)**</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.32</td>
<td>0.33</td>
<td>0.39</td>
</tr>
<tr>
<td>Number of observations</td>
<td>5,525,420</td>
<td>4,274,790</td>
<td>5,522,718</td>
</tr>
</tbody>
</table>

All regressions have country×sector×year fixed-effects. Standard errors are in parentheses and are clustered at country level. ** denotes significant at the 1% level.
in countries with a recovery rate below the median.

$$\log TFP_{c,a} = \theta_1 (Age < 4) + \ldots + \theta_5 (Age > 18) + dummies + \varepsilon$$  \hspace{1cm} (14)

Results of the estimation are present in Table 8.

Table 8: Age-effect on productivity

<table>
<thead>
<tr>
<th>Age</th>
<th>High RR</th>
<th>Low RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>[4, 7]</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.0013)**</td>
<td>(0.0026)**</td>
</tr>
<tr>
<td>[8, 11]</td>
<td>0.05</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>(0.0013)**</td>
<td>(0.0024)**</td>
</tr>
<tr>
<td>[12, 18]</td>
<td>0.06</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>(0.0012)**</td>
<td>(0.0029)**</td>
</tr>
<tr>
<td>&gt; 18</td>
<td>0.09</td>
<td>-0.37</td>
</tr>
<tr>
<td></td>
<td>(0.0013)**</td>
<td>(0.0060)**</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.06</td>
<td>0.14</td>
</tr>
<tr>
<td>Number of observations</td>
<td>4,331,012</td>
<td>1,194,408</td>
</tr>
</tbody>
</table>

All regressions have country×sector×year fixed-effects. Standard errors are in parentheses and are robust to heteroskedasticity. ** denotes significant at the 1% level.

4.2 Share of Entrant Firms

The second prediction of the model (lemma ) is that, due to a high firm turnover, the share of young firms is relatively higher in countries with better recovery rate.\footnote{Before verifying this prediction a disclaimer is in order. This particular testing is highly sensitive to sample selection, as it is plausible that younger firms are relatively more under-represented. Therefore I consider the numbers of this test an indication of the results, rather than the documentation of a fact.}

Before verifying this prediction we must note that this particular testing is highly sensitive to sample selection, as it is plausible that certain groups of firms are relatively underrepresented. Therefore, and for this test, I analyze the coverage and comparability of the Amadeus dataset across countries. In this exercise, I compare the coverage of the Amadeus dataset with the data present in the European Comission report. The latter report contains information on the distribution of the universe of firms per number of employees. Therefore, I follow Arellano (2010) in comparing the fraction of firms, for each employment
category, in the Amadeus dataset with that in the universe from the report. Furthermore, and given that my sample is from 2002 to 2005, it is likely that Eastern European economies are still in transition from the end of the Communist regime. This presents the possibility that Eastern European countries have a different distribution of older firms simply due to this ongoing transition. I attempt to control for this possibility by restricting the sample to countries that have at least 1 percent of firms with more than 15 years old.

To test whether it is true that countries with better recovery rate present a higher share of young firms I run

\[ Shrent_c = \alpha_0 + \alpha_1 \log RR_c + \varepsilon_c \]

where \( Shrent \) represents the fraction of firms with less than 5 years and \( RR \) the recovery rate. I present the results in the first column of Table ???. The coefficient of interest \( \alpha_1 \) is positive but it is not significantly different from zero.

In Figure 4.2, I graph the results, along with the fitted regression.

---

43 From the European Comission Report, we have that for all the countries in the sample the share of large firms (i.e. >250 employees) is on average 6.9%. In this exercise, I discarded countries whose share of larger firms was larger than 25%. This leads me to discard the Dutch data, as its share of large firms represents 31.4 percent of the as the share of small firms. If I altered the cutoff to 10% Poland and Ukraine would also be excluded.

44 Using this criterium I exclude the Czech Republic, Estonia, Hungary, Latvia, Lithuania and Romania.
4.3 Growth

Another important result of the model (proposition) is that firms, and in particular young firms, grow faster in countries with low Recovery Rate. To test the validity of the prediction I estimated

$$salgrt_i = \alpha_0 + \alpha_1 \ln(age_i) + \alpha_2 (\ln(age_i) \times \ln(RR_{c})) + \text{dummies} + \varepsilon_i$$

where the dependent variable $salgrt_i$ is the growth of sales and the regressors are log of the recovery rate, the log of the firm age, the interaction between the log of age and the log of recovery rate, and country×sector×year fixed-effects. The first column of Table 9 presents the results of the regression. The coefficients are significant and of the expected sign. Growth decreases with age overall, and the growth rate decreases faster with age in countries with worse recovery rates. The difference in growth rates of the median 1-year old firm and the median 10-years-old is 5 percentage points higher in Russia than in United Kingdom. This difference is significant since average sales yearly growth in Russia are 35 percent.

<table>
<thead>
<tr>
<th>Table 9: Recovery Rate and Sales Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Sample</td>
</tr>
<tr>
<td>log ($Age_{i,t}$)</td>
</tr>
<tr>
<td>(0.01)**</td>
</tr>
<tr>
<td>log ($Age_{i,t}$) × log ($RR_c$)</td>
</tr>
<tr>
<td>(0.009)**</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
</tr>
<tr>
<td>Number of observations</td>
</tr>
</tbody>
</table>

Regressions have ctry×sector×year fixed-effects. Std. errors are in parentheses and clustered at country level. ** denotes significant at the 1% level.

In the second column of Table 9 I present the results of the same estimation, but restricting the sample to firms with less than 15 years. The results still hold and remain economically significant.

Other explanations

Arellano, Bai and Zheng (2010) document that smaller firms grow faster than older ones especially in countries with better financial development.\(^{15}\)

\(^{15}\) Arellano et al use size of the financial system to proxy for Financial Development. They use two different indicators. The ratio of private credit to GDP and the percentage of population covered by national credit bureaus. As documented in section XXX there is high correlation between recovery rate and the ratio of private credit to GDP.
They argue that firms in countries with worse financial development grow faster to decrease financing costs. To account for this explanation, and given the high correlation between age and size, I estimate the same regression including \( \log(\text{AsstShr}_{i,c}) \) as a measure of size.\(^{46}\) The results are present in the third column of Table 9 and the coefficients of interest remain with the same signal and magnitude.

### 4.4 Leverage

The model also has some predictions regarding the leverage dynamics (proposition ). The model predicts that the rate at which firms deleverage is increasing in the country’s recovery rate. To test this hypothesis I run

\[
lev_i = \alpha_0 + \alpha_1 \ln(age_i) + \alpha_2 \ln(age_i) \cdot \ln(RR_c) + \text{dummies} + \varepsilon_i
\]

with leverage as the dependent variable, and where the regressors are firm age and the interaction of age with the log of the recovery rate, along with country and sector fixed-effects.\(^{47}\) The first column of Table 10 reports the estimated coefficients. As predicted by the model, the coefficient on firm age is negative indicating that firms deleverage with age, while the coefficient of the interaction term is positive implying that the speed of deleverage is increasing in debt enforcement.

<table>
<thead>
<tr>
<th>Table 10: Recovery Rate and Leverage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>log(Age)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>log(RR) \times log(Age)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Adjusted R-squared</td>
</tr>
<tr>
<td>Number of observations</td>
</tr>
</tbody>
</table>

All regressions have country×sector×year fixed-effects. Standard errors are in parentheses and are robust to heteroskedasticity. ** denotes significant at the 1% level.

**Other Explanations**

Arellano et al document that size has important effect on firm dynamics in

\(^{46}\)The measure for size \( \log(\text{AsstShr}_{i,c}) \) is the log share of firm \( i \) assets to total firm assets in country \( c \).

\(^{47}\)Leverage is measured as the accounting ratio between total liabilities and total assets.
that higher collateralization In the second column I report that the results of the estimation are robust to the truncation of the sample to firms with less than 10 years of age.

4.5 Income Level

The model has a prediction on income which states that the income level is increasing in recovery rate. To attest the veracity of this prediction I run

$$\log Y_c = \alpha_0 + \alpha_1 \ln RR_c + \varepsilon_c$$

where the dependent variable is the log of income per capita in PPP while the regressor in the log of the recovery rate. The data for this regression was taken from the Penn World Tables 6.3 and I used the data for 2004. The data from the recovery rate was from 2004 and it was taken from Doing Business.

The results of this regression are in the first column of Table 11.

<table>
<thead>
<tr>
<th>Table 11: Recovery Rate and Income Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Sample</td>
</tr>
<tr>
<td>log(RR)</td>
</tr>
<tr>
<td>(0.0814)**</td>
</tr>
<tr>
<td>Number of observations</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
significant at 5%; ** significant at 1

4.6 Aggregate Productivity

Finally, the model predicts that aggregate productivity is increasing with recovery rate. To test this hypothesis I run

$$\log TFP_c = \alpha_0 + \alpha_1 \ln RR_c + \varepsilon_c$$

where the dependent variable is the log of TFP while the regressor in the log of the recovery rate. The results of this regression are in the first column of Table 12.

48 I calculate TFP as

$$TFP_c = \frac{GDP_c}{K^{0.33}L^{0.67}}$$
Table 12: Recovery Rate and Income Level

<table>
<thead>
<tr>
<th></th>
<th>All Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>log(RR)</td>
<td>0.3683</td>
</tr>
<tr>
<td>(0.0475)**</td>
<td></td>
</tr>
<tr>
<td>Number of observations</td>
<td>132</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
significant at 5%; ** significant at 1

5 Conclusion

In this paper I have developed a novel theory of aggregate income, linking the quality of debt enforcement with the cost of debt and consequently with firm selection and aggregate productivity. Quantitative simulations of the model show that the quality of debt enforcement has sizeable effects on both the output and aggregate productivity. The main reason for these aggregate effects is related with variations in the risk-premium of debt. In economies with higher recovery rate, a proxy for debt enforcement, lenders demand a lower risk-premium allowing firms to achieve their optimal size relatively faster. Furthermore, the impact of this lower risk-premium is larger for the riskier young firms. The decrease in the cost of debt, increases the outside option of starting a new project from scratch. This selection effect has an important impact on aggregate productivity by promoting the exit of lower quality projects. A testable implication of this mechanism is that older firms should be relatively more productive in countries with better debt enforcement, where this firm turnover is stronger. I present empirical evidence that this effect is significantly present in the data. Additionally, the model presents a series of novel predictions on firm dynamics such as leverage and growth. For example, I document that the initial firm size and the speed of deleverage are both increasing in the recovery rate.

Finally, I study the optimal punishment for default, measured as the expected time of exclusion from the credit markets after insolvency. I show that the optimal punishment is decreasing in the quality of debt enforcement. This happens as the value of decreasing the probability of default, and consequently the risk-premium, is larger in an environment with a low recovery rate.

where GDP is the gross production at international prices, $K_e$ is the total capital in the economy, and $L_e$ is the total population. The initial capital for each country was calculated using the perpetual inventory method.
6 References

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Arellano, C., Y. Bai, and Jing Zhang, "Firm Dynamics and Financial Development" (2010)


Dorleac, Thierry, "La procedure de sauvegarde: un "Chapter 11" a la francaise?" (2005), Blog juridique du village de la Justice.

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7 Appendix

7.1 Analytical Model - Proofs

Proof. (Lemma 1) - Note that 9 can be written as

\[ V^o = \frac{z^* - R^L}{R^H} \frac{(1 - \pi^* (1 - \xi)) B^* + \beta (1 - \phi) (1 - \pi^*) (z^* - R^t) \xi}{1 - \pi^* (1 - \phi)} \]

Given two economies \{L, H\} with different recovery rates \( \xi_L < \xi_H \). Assume that while firms in country L chose their optimal debt \( B^*_L \) firms in country H choose their debt such that \( \pi_L = \pi_H \). In this case the only varying part in \( V^o \)
is \((1 - \pi^e (1 - \xi)) B^e\). We know that for \(\pi_L = \pi_H\) to occur it must be \(\tilde{\xi}_L = \tilde{\xi}_H\). Given the indifference condition 12 this implies that \(V_L^o + B_L (1 - \xi_L) = V_H^o + B_H (1 - \xi_H)\). If \(V_H^o < V_L^o\) then it must be that \(B_H > B_L\). But in this case \(V_L^o - V_H^o = \frac{e^{\gamma B^L}}{1 - e^{(1 - \phi)(1 - \xi)}} ((1 - \pi (1 - \xi_H)) B_H - (1 - \pi (1 - \xi_L)) B_L) > 0\) which is a contradiction. Hence \(V_H^o > V_L^o\). ■

Proof. (Proposition 12) - We want to prove that \(\tilde{\xi}_L < \tilde{\xi}_H\) and that \(\xi < \tilde{\xi}\).

The first part of the proof is done by contradiction. Assume that \(\tilde{\xi}_L > \tilde{\xi}_H\).

From the indifference condition

\[
\tilde{\xi} = \frac{1 - \beta (1 - \phi)}{\kappa} (V^o + (1 - \xi) B^e) + R^f
\]

(15)

this implies that \(B^e_L > B^e_H\). The optimal \(B^e\) is such that \(\frac{\partial V^o}{\partial B} = 0\). Maximizing \(V^o\) with respect to \(B\) gives us

\[
\frac{\partial V^o}{\partial B} = \frac{z^e - R^f}{R^f} \left(1 - \pi^e (1 - \xi) - \frac{\partial \pi}{\partial B} (1 - \xi) B\right) + \beta (1 - \phi) \left(\frac{\partial \pi^e}{\partial B} V^o - \left(\frac{\partial \pi}{\partial B} \frac{1}{2}\right) Y\right)
\]

where \(Y \equiv \frac{\kappa}{1 - \beta (1 - \phi)}\). In the optimum the condition becomes

\[
B^* = \frac{Y}{(1 - \xi) \left(1 + \frac{1 - \phi}{z^e R^f}\right)} \left(\pi - \tilde{\xi}\left(\frac{1}{1 - \xi - \pi} + (1 - \phi) R^f\right)\right)
\]

(16)

but given the assumption that \(\tilde{\xi}_L > \tilde{\xi}_H\) this implies that \(B^*_L < B^*_H\) which is a contradiction. Hence \(\tilde{\xi}_L < \tilde{\xi}_H\).

Now we want to prove that \(\xi < \tilde{\xi}\). Given that \(\tilde{\xi}_L < \tilde{\xi}_H\) we have to prove \(\xi < \tilde{\xi}_{\xi=0}\). Again let’s prove this by contradiction. Assume that \(\xi \geq \tilde{\xi}_{\xi=0}\), this implies that \(\pi_{\xi=0} = 0\). From the indifference condition it must be that \(\tilde{\xi} = B + \beta (1 - \phi) V^o < g \xi Y\) where \(Y \equiv \frac{\kappa}{1 - \beta (1 - \phi)}\).

From the expression above on debt we know that the optimal debt when \(\xi = 0\) is

\[
B^*_\xi=0 = \frac{Y \left((\pi - \tilde{\xi}) + (1 - \phi) R^f\right)}{1 + \frac{1 - \phi}{z^e R^f}}
\]

hence \(\xi < \tilde{\xi}\). ■

Proof. (Proposition 4) - In this prove we want to show that \(k^e_L < k^e_H\). This
proof will be done using contradiction arguments. As entrepreneurs start a project with no capital we have $k^e_j = \frac{R^e_j}{R^f_j} = \frac{P^e_j}{P^f_j (1-\pi_c (1-\xi_j))}$.

We know that the expected value of an entrant firm is

$$V_j^o = \frac{z^e - R^f_j}{R^f_j} k^e_j + \beta (1 - \phi) \left( \pi_c V_j^o + (1 - \pi_c) \frac{z^i_L - R^i_f}{1 - \beta (1 - \phi)} k^i_f L \right)$$

and this can be rewritten as

$$V_j^o = \frac{P^e_j + (1 - \pi_c) (z^i - R^i_f) W}{1 - \gamma \pi_c}$$

where $P^e_j \equiv \frac{z^e - R^f_j}{R^f_j} k^e_j$ and $W \equiv \beta (1 - \phi) \frac{z^e}{1 - \beta (1 - \phi)}$. In order for $k^e_L < k^e_H$, it must be that $P^e_L < P^e_H$. We know that $V_j^o < V_H$ and $\pi_L < \pi_H$. This implies

$$(1 - \gamma \pi_H) (P^e_L + (1 - \pi_L) (z^L - R^f_L) W) < (1 - \gamma \pi_L) (P^e_H + (1 - \pi_H) (z^H - R^f_H) W)$$

Using the fact that $\pi_c = \frac{z^e}{P^e_j}$ and assuming that $P^e_L = P^e_H$ the expression above simplifies to

$$\frac{P^e_H}{V} (\pi_L - \pi_H) + (1 - \gamma \pi_H) \left( \pi^2 - \pi^2_L \right) < (1 - \gamma \pi_H) \left( \pi^2 - \pi^2_H \right)$$

\begin{proof}
(Proposition 4.4) - Leverage is defined as $Lev_t = B^e_t$. Since firms deleverage as fast as possible then the leverage of a firm with $\tau$ years is

$$Lev^\tau = Max \left\{ 0, \frac{B_{\tau-1} - (z_i - R^f_i) k^\tau}{k^\tau} \right\}$$

which indicates that firm pays its outstanding debt $B_{\tau-1}$ with the profits it generates $(z_i - R^f_i) k^\tau$. As $k^e$ is increasing in $\xi$ we have that $\frac{\partial^2 Lev}{\partial \tau \partial \xi} < 0$ which implies that firms deleverage faster with higher recovery rate. \end{proof}

\begin{proof}
(Proposition 7) - Income level is

$$Y = \lambda y^e + (1 - \lambda) y^i$$

$$= y^i + \lambda y^e + \lambda y^i$$

46
The first two terms are clearly increasing in $\bar{e}$ and therefore in $\xi^{49}$. The last term can be written as

$$y^i = \frac{\bar{e} + \bar{e}^i}{1 + \frac{1}{\phi} (1 - \bar{e})}$$

Differentiating it with respect to $\bar{e}$ gives us

$$\frac{\partial y^i}{\partial \bar{e}} = \frac{1 + \frac{1}{\phi} + \frac{\lambda}{2(1-\bar{e})}}{\left(1 + \frac{1}{\phi} (1 - \bar{e})\right)^2} > 0$$

Since $\frac{\partial y}{\partial \xi} > 0$ we have the result $\frac{\partial Y}{\partial \xi} > 0$.  

**Proof.** (Lemma 3.2.3) - Average productivity is measured as

$$z^{avg} = \lambda \frac{\bar{e} + \bar{e}}{2} + (1 - \lambda) \frac{\bar{e} + \bar{e}^i}{2} = \frac{\bar{e}}{2} + \frac{\lambda (\bar{e} - \bar{e}) + \bar{e}}{2}$$

focusing on the variable part and using the definition of $\lambda$ we have

$$\lambda (\bar{e} - \bar{e}) + \bar{e} = \frac{\bar{e} + \bar{e}^i - \frac{2^2}{\bar{e}}}{1 + \frac{1}{\phi} (1 - \bar{e})} = \phi \theta^h + \bar{e} - \frac{2^2}{\bar{e}}$$

in this last expression only $\bar{e}$ depends on $\xi$. Differentiating it with respect to $\bar{e}$ gives us

$$\frac{\partial \lambda (\bar{e} - \bar{e}) + \bar{e}}{\partial \bar{e}} = \frac{1 + 2 \phi + \frac{2^2}{\bar{e}} - \frac{2^2(1+\phi)}{\bar{e}}}{(1 + \phi - \frac{2}{\bar{e}})^2} > 0$$

As $\frac{\partial Y}{\partial \xi} > 0$ we have the result $\frac{\partial z^{avg}}{\partial \xi} > 0$.  

**Proof.** (Proposition 3.2.3) - Overall productivity is measured as

$$z^{prod} = \frac{Y}{K} = \frac{\lambda \frac{\bar{e} + \bar{e}}{2} k_e + (1 - \lambda) \frac{\bar{e} + \bar{e}^i}{2} k^i}{\lambda k_e + (1 - \lambda) k^i}$$

\[49\] We have shown above that both $\tilde{\theta}$ and $k^E$ are increasing in $\xi$. Therefore both $y^i = \frac{\tilde{\theta} + \theta H}{2}$ and $\lambda y^E = \frac{\tilde{\theta} + \theta H}{1 + \frac{1}{\phi} (1 - \bar{e})}$ are also increasing in $\xi$.  

47
which, given $\bar{z} < \tilde{z}$, implies that the larger $k^e$ the lower $z^{prod}$. $k^e$ is capped by $\tilde{k}$. if $k^e = \tilde{k}$ then $z^{prod} = z^{avg}$. From proposition ?? we know that $\frac{\partial z^{avg}}{\partial k} > 0$. Therefore we have the result $\frac{\partial z^{prod}}{\partial k} > 0$.

7.2 Computational Algorithm

7.2.1 Setup

The numerical problem has four state variables. Capital, debt, productivity and age. I discretize all state variables and compute the solution using value function iteration. A solution is found when a fixed point is found such that the value function does not vary, the probability of default does not change and the capital and labor supplied is equal to its demand.

7.2.2 Productivity

Productivity has a lognormal distribution such that

$$
\ln z_{i,t} = (1 - \rho) \ln z + \rho_{t} \ln z_{i,t-1} + \varepsilon_{i,\tau,t}
$$

$$
\varepsilon_{i,\tau} \sim N \left( 0, \sigma_{\varepsilon,\tau}^2 \right)
$$

To discretize the productivity process $z$ I followed the approach in Tauchen (1986). Let $\tilde{z}$ denote the discrete-valued process that approximates the continuous process $z$, and let $\tilde{z}^1 < \tilde{z}^2 < \ldots < \tilde{z}^N$ denote the values that $\tilde{z}$ may take on. I calculate the transition matrix $p_{jk} = \Pr \left[ \tilde{z}_t = \tilde{z}^k \mid \tilde{z}_{t-1} = \tilde{z}^j \right]$ as follows. Using $w = \tilde{z}^k - \tilde{z}^{k-1}$ then for each $j$ if $k$ is between 2 and $N - 1$ set

$$
p_{jk} = \Pr \left[ \frac{\tilde{z}^k - \frac{w}{2}}{\sigma_{\varepsilon}} \leq (1 - \rho) \ln z + \rho_{t} \ln z_{i,t-1} \leq \frac{\tilde{z}^k + \frac{w}{2}}{\sigma_{\varepsilon}} \right]
$$

$$
= F \left( \frac{\tilde{z}^k - (1 - \rho) \ln z - \rho_{t} \ln z_{i,t-1} + \frac{w}{2}}{\sigma_{\varepsilon}} \right) - F \left( \frac{\tilde{z}^k - (1 - \rho) \ln z - \rho_{t} \ln z_{i,t-1} - \frac{w}{2}}{\sigma_{\varepsilon}} \right)
$$

otherwise

$$
p_{j1} = F \left( \frac{\tilde{z}^1 - (1 - \rho) \ln z - \rho_{t} \ln z_{i,t-1} + \frac{w}{2}}{\sigma_{\varepsilon}} \right)
$$

$$
p_{jN} = 1 - F \left( \frac{\tilde{z}^N - (1 - \rho) \ln z - \rho_{t} \ln z_{i,t-1} - \frac{w}{2}}{\sigma_{\varepsilon}} \right)
$$

48