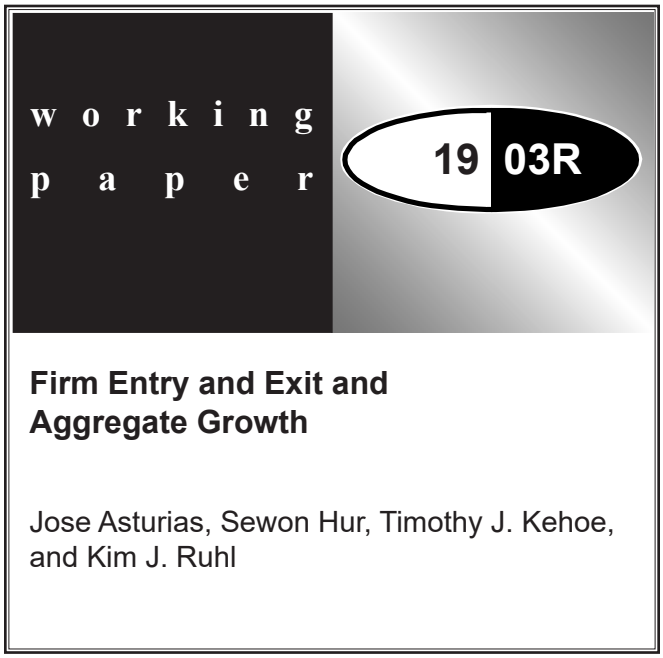


# Firm Entry and Exit and Aggregate Growth

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Applying the Foster, Haltiwanger, and Krizan (FHK) (2001) decomposition to plant-level manufacturing data from Chile and Korea, we find that the entry and exit of plants account for a larger fraction of aggregate productivity growth during periods of fast GDP growth. Studies of other countries confirm this empirical relationship. To analyze this relationship, we develop a simple model of firm entry and exit based on Hopenhayn (1992) in which there are analytical expressions for the FHK decomposition. When we introduce reforms that reduce entry costs or reduce barriers to technology adoption into a calibrated model, we find that the entry and exit terms in the FHK decomposition become more important as GDP grows rapidly, just as they do in the data from Chile and Korea.

Keywords: entry, exit, productivity, entry costs, barriers to technology adoption..

JEL Codes: E22, O10, O38, O47.

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## 1. Introduction

Findings in empirical studies vary widely on the importance of the entry and exit of plants in accounting for aggregate productivity growth. Consider, for example, two widely cited studies: Foster, Haltiwanger, and Krizan (FHK) (2001) find that the entry and exit of plants account for 25 percent of U.S. manufacturing productivity growth, while Brandt, Van Biesebroeck, and Zhang (2012), using the same methodology, find that entry and exit account for 72 percent of Chinese manufacturing productivity growth.[1] In this paper, we account for the stark differences in the U.S. and Chinese data by examining data from other countries and by developing a simple model in which we can understand the driving forces behind those differences.

The first contribution of this paper is empirical. We apply the FHK decomposition to plant-level manufacturing data from Chile and South Korea. We find that plant entry and exit account for a larger fraction of aggregate manufacturing productivity growth during periods of fast growth in GDP per working-age person. A meta-analysis of the productivity literature, spanning a number of countries and time periods, supports this empirical regularity. We summarize our findings in Figure 3, in which we plot growth in GDP per working-age person against the contribution of the entry and exit of plants to growth in aggregate manufacturing productivity. This empirical relationship is novel in the literature and suggests that the entry and exit of plants play an important role in explaining periods of fast growth. Furthermore, we find that in the case of Chile and Korea, the changes in the contribution of entry and exit are accounted for by changes in the relative productivity of entering and exiting plants and not their market shares.

Our second contribution is theoretical. We develop a dynamic general equilibrium model with endogenous entry and exit, based on Hopenhayn (1992), that can quantitatively account for the patterns we document in the data. Our model is simple enough that there are analytical expressions for the terms in the FHK decomposition. When we introduce reforms that reduce entry costs or reduce barriers to technology adoption into a calibrated model, we find that both the entry and exit terms in the FHK decomposition become more important as GDP grows rapidly, just as they do in

[1] To calculate that entry and exit account for 25 percent of U.S. manufacturing productivity growth, see Table 8.7 in FHK and find the average net entry share for the 1977–1982, 1982–1987, and 1987–1992 windows. To find the contribution of entry and exit in China, see Figure 7 in Brandt, Van Biesebroeck, and Zhang (2012).

the data. Our simple model, meant to highlight the forces driving productivity growth, performs surprisingly well in quantitatively matching the behavior we observe in the data.[2]

Chile and Korea are good candidates for our empirical analysis because both countries have experienced periods of fast and slow growth. Real GDP per working-age person in Chile grew 4.0 percent per year during 1995–1998, slowing to 2.7 percent per year during 2001–2006. In Korea, real GDP per working-age person grew by 6.1 percent per year in 1992–1997 and by 4.3 percent per year in 2001–2006 and slowed to 3.0 percent per year in 2009–2014.

Following FHK, we decompose the Chilean and Korean plant-level data into a net entry term and a continuing plant term. The net entry term is higher if entering plants or exiting plants have relatively large market shares, if entering plants are relatively productive, or if exiting plants are relatively unproductive, compared to the industry average. The continuing plant term consists of both within-plant productivity growth and the reallocation of market shares across continuing plants. We find that, in both countries, net entry accounts for a larger fraction of aggregate manufacturing productivity growth during periods of fast GDP growth. During periods of slow growth, when GDP per working-age person grows at less than 4 percent per year, entry and exit account for less than 25 percent of aggregate manufacturing productivity growth on average, similar to the average contribution of entry and exit in the United States. During periods of fast GDP growth, however, entry and exit account for a larger fraction of aggregate manufacturing productivity growth, ranging from 37 to 58 percent. Our findings are robust to using alternative decompositions.

In addition, we investigate how the relative productivity of entering and exiting plants as well as their market shares evolved in Chile and Korea over these time periods. We find that the periods of fast growth tend to have relatively productive entering plants compared to periods of slow growth. Furthermore, we find that exiting plants tend to be relatively unproductive during periods of fast growth, suggesting that there is an increased selection effect of plants with low productivity. We also do not find consistent changes in the market shares of entering and exiting plants during the periods of fast and slow growth. These intuitive moments (relative productivities and market

[2] Our general equilibrium model is of the entire economy, but, because of data limitations, the productivity decompositions in both the existing literature and our own work cover only the manufacturing sector. In order to make comparisons between the model and the data, we assume that the contribution of net entry in the non-manufacturing sector behaves identically to that in the manufacturing sector.

shares of entering and exiting plants) are inputs into the FHK contribution of net entry and help us better understand the changes in the importance of entry and exit that we observe.

Studying periods of slow and fast growth in the same country allows us to avoid cross-country differences and to use consistent data sets through time, reducing measurement problems. Nonetheless, it is also useful to get a broader understanding of the empirical relationship between growth and the role of net entry across countries. Our own analysis is limited by the availability of establishment-level data, and fortunately, the FHK decomposition is widely used in the productivity literature. We survey papers in the literature that use the FHK decomposition. One immediate challenge we face is that studies in the literature use windows of different time lengths, making it difficult to compare the results of these studies because the FHK decompositions are sensitive to window length (that is, longer windows are associated with higher contributions of entry and exit). We develop a methodology to adjust the results from studies that use different windows than ours in order to ensure comparability. We find that continuing establishments consistently account for the bulk of aggregate manufacturing productivity growth when GDP per working-age person grows slowly. During episodes of fast GDP growth, the entry and exit of plants become increasingly important in accounting for productivity growth.

These findings suggest that policymakers aiming to replicate fast-growth experiences like those experienced by Chile and Korea should focus on reforms that increase the contribution of entry and exit. In order to study the types of reforms that can account for these empirical regularities, we build a simple model with three sources of aggregate productivity growth. First, in each period, potential entrants draw efficiencies from a distribution with a mean that grows at rate $g_e - 1$. Second, continuing firm efficiencies improve with age. This efficiency growth depends on an exogenous growth factor and spillovers from average efficiency growth. Finally, firms choose when to exit production, which induces a selection effect in which inefficient firms exit.

The economy is subject to three types of distortions. First, a potential entrant must pay an entry cost to draw an efficiency. Second, a successful entrant must pay a fixed cost to continue production in each period. These two costs are partly technological and partly the result of policy. We think of the policy-related costs as distortions that can be reduced through economic reform. Third, new firms face barriers to technology adoption in the spirit of Parente and Prescott (1994). Better technologies exist but are not used because of policies that restrict their adoption.

We show that the model has a balanced growth path on which income grows at the same rate regardless of the severity of the policy distortions. Income levels on the balanced growth path, however, are determined by the distortions: More severe distortions yield lower balanced growth paths. These results are consistent with the data from the United States and other industrialized economies, which have grown at about 2 percent per year for several decades, despite persistent differences in income levels. Kehoe and Prescott (2002) and Jones (1995) provide an in-depth discussion of these empirical regularities.

The simplicity of our model allows us to characterize analytically the FHK decompositions of the model on the balanced growth path. The decompositions highlight the ways that firm turnover, selection, and the efficiency advantage of entrants affect the contribution of net entry to aggregate productivity growth. For example, we show that if there is a decline in within-cohort heterogeneity (that is, incoming firms have more similar efficiency draws), then the contribution of net entry increases. The reason is that reducing within-cohort differences in efficiency increases the importance of the efficiency differences across cohorts. We also show that the contribution of net entry also increases with a parameter related to firm turnover. Furthermore, an increase in the growth rate of continuing firms also leads to a decline in the contribution of net entry. These forces are present in many growth models in the literature, and our model allows us to understand how they map into empirical decompositions.

We calibrate the model to the U.S. economy in which entry and exit account for 25 percent of U.S. aggregate productivity growth. In order to study the kinds of reforms that could potentially account for the patterns we observe during periods of fast growth, we then create three separate distorted economies to evaluate reforms to entry costs, barriers to technology adoption, and fixed continuation costs. The spirit of the exercise is that these distorted economies are exactly the same as the U.S. economy except for the policy distortion we are studying. We increase one of the distortions in each economy so that the balanced growth path income level is 15 percent below that of the United States. On the balanced growth path, each of these distorted economies grows at 2 percent per year and net entry accounts for 25 percent of aggregate productivity growth in the FHK decomposition.

We remove the distortion in each economy and study the transition to the higher balanced growth path. When we lower entry costs, the GDP growth rate rises to 4.6 percent per year for five years, and net entry accounts for 60 percent of aggregate productivity growth. Even though net

entry is relatively unimportant on the balanced growth path, the model matches the increasing importance of net entry in the FHK decomposition during periods of fast GDP growth. Moreover, the reform features the entry of relatively efficient firms and the exit of relatively inefficient firms, as in the data.

When we decrease the barriers to technology adoption in the model, GDP growth and the importance of net entry to aggregate productivity growth along the transition are almost identical to that in the lower-entry-costs experiment. While both reforms generate the positive correlation between GDP growth and the importance of net entry that we observe in the data, the underlying mechanisms are very different.

Lower entry costs increase the number of potential firms that draw efficiencies. The larger number of potential firms drives up the efficiency threshold for entry, which increases aggregate productivity: More entry leads to higher productivity. This mechanism is very much in the spirit of Schumpeter (1942). Causation in the case of lower barriers to technology adoption runs in the opposite direction. When it is easier for firms to adopt higher efficiencies, the value of operating a firm increases. This increase in firm value leads to more potential firms drawing efficiencies: Higher productivity leads to more entry.

The model in which more entry leads to higher productivity is very similar to the one in which higher productivity leads to more entry, except in one dimension: the number of potential entrants is larger in the experiment with decreased entry costs. In both cases—lower entry costs and lower barriers to technology adoption—reforms increase the value of operating a firm, which leads to more potential entrants. The lower entry cost also directly changes the cost of entry, which has an additional effect on the mass of potential entrants.

Measuring potential entrants in the data raises several challenges. What is the data counterpart to a potential entrant paying to draw an efficiency but choosing not to operate the technology? Perhaps failed entrants are people who developed a business idea but either did not follow through with it or started the business and failed. The latter may be captured in the firm-level data but the former may not. A related issue is one of duration. If a business fails after one year, is it a failed entrant? What if it fails after two years? These issues arise not just in our work, but also in the countless other papers that consider costly firm entry. Hurst and Pugsley (2011) and Choi (2017) provide some insight into the start-up data and why entrants fail.

Not all the reforms we consider generate dynamics consistent with the data. When we lower the fixed continuation cost in the model, GDP growth increases, but aggregate productivity decreases. A lower fixed continuation cost allows less-productive firms to enter and less-productive firms to remain in production, which results in decreasing aggregate productivity during periods of fast GDP growth. This is not the case in any of the episodes we study in Chile and Korea, nor is it the case in any of the episodes we study in the literature. Furthermore, we document that the reforms that Chile and Korea implemented are consistent with lowering entry costs and barriers to technology adoption.

We find that other types of reforms in the model are inconsistent with the patterns we observe in the data. For example, reforms that lead to the same efficiency improvement for all firms do not account for an increase in the importance of entry and exit. The reason is that a common efficiency improvement benefits both incumbents and entrants equally. We can also exclude reforms that improve the efficiency of incumbents more than that of entrants. For example, a reform that only improves the efficiency of incumbent firms would lead to declines in the importance of entry and exit during the transition.

Closest to our work is that of Garcia-Macia, Hsieh, and Klenow (2016), who derive a model-based decomposition to measure the fraction of growth in the economy due to incumbents and to entrants. Their primary finding—that the bulk of growth in the U.S. economy is due to incumbents—is consistent with our own findings for slow-growing economies.

In contrast to their work, we use the FHK decomposition. While it is not derived from a structural model, it is widely used in the literature, allowing us to use the findings from other papers to complement our study of Chile and Korea. In comparison with Garcia-Macia, Hsieh, and Klenow (2016), the scope of our study is broader: In addition to the United States, we study many countries and trace out the importance of net entry in productivity growth in both fast- and slow-growing economies.

Our model is related to other papers that attempt to understand how the FHK decomposition is related to structural models of firm entry and exit. We are the first to characterize analytically the FHK decomposition along the balanced growth path of a general equilibrium model, but other papers, such as Acemoglu et al. (2013), Arkolakis (2015), and Lentz and Mortensen (2008), have used the FHK decomposition to compare calibrated models to the data.

Our modeling approach is related to the endogenous growth literature in which productivities are drawn from a distribution that improves over time (see Alvarez, Buera, and Lucas 2017; Buera and Oberfield 2016; Lucas and Moll 2014; Perla and Tonetti 2014; Sampson 2016). Relative to these papers, we take a simplified approach where the productivity distribution from which entrants draw improves at an exogenous rate, which is similar to Luttmer (2007). The idea that potential entrants in any economy can draw their productivity from the frontier productivity distribution is related to the literature on technology diffusion and adoption (see Parente and Prescott 1999; Eaton and Kortum 1999; Alvarez, Buera, and Lucas 2017).

Our empirical analysis is broadly related to the productivity decomposition literature (Baily, Hulten, and Campbell 1992; Griliches and Regev 1995; Olley and Pakes 1996; Petrin and Levinsohn 2012; Melitz and Polanec 2015), which develops methodologies for decomposing aggregate productivity. These types of decompositions are often used to study the effect of policy reform (Olley and Pakes 1996; Pavcnik 2002; Eslava et al. 2004; Bollard, Klenow, and Sharma 2013). Our work is the first to document the empirical relationship between the importance of plant entry and exit in the FHK decomposition and aggregate growth in GDP per working-age person. These empirical results suggest that the entry and exit of firms are important ingredients in fast economic growth. It also provides empirical facts that can be used to discipline models that study productivity growth in fast-growing countries.

Finally, our paper is related to a series of papers that use quantitative models to study the extent to which entry costs can account for cross-country income differences (Herrendorf and Teixeira 2011; Poschke 2010; Barseghyan and DiCecio 2011; Bergoeing, Loayza, and Facundo 2011; D'Erasmo and Moscoso Boedo 2012; Moscoso Boedo and Mukoyama 2012; D'Erasmo, Moscoso Boedo, and Senkal 2014; Bah and Fang 2016; Asturias et al. 2016). Distortions in our model also drive differences in balanced growth path income levels, but our focus is on the behavior of productivity and entry and exit dynamics during the transition between balanced growth paths.

In Section 2, we use productivity decompositions to document the positive relationship between the importance of entry and exit in aggregate manufacturing productivity growth and the growth in GDP per working-age person in the economy. Section 3 lays out our dynamic general equilibrium model, and Section 4 discusses the existence and characteristics of the model's balanced growth path. In Section 5, we discuss the measurement of productivity in the model. In

Section 6, we present analytical characterizations of the FHK decomposition of the model on the balanced growth path. In Section 7, we conduct quantitative exercises to show that the calibrated model replicates the empirical relationship we find in Section 2. Section 8 concludes and provides directions for future research.

## 2. Productivity Decompositions

In this section, we use the FHK productivity decomposition on Chilean and Korean manufacturing data to decompose changes in aggregate manufacturing productivity into the contribution from entering and exiting plants and the contribution from continuing plants. We find that, compared to periods of slow growth in GDP per working-age person, the entry and exit of plants account for a larger share of aggregate manufacturing productivity growth during years of fast growth in GDP per working-age person. We additionally investigate whether these results are driven by the productivity of entering and exiting plants or in their market shares, which are inputs into the FHK net entry term.

We then analyze previous work on plant entry and exit and aggregate manufacturing productivity. This literature was not explicitly focused on the role of entry and exit during different kinds of growth experiences. Studies in the literature use window lengths of varying sizes, which poses a challenge because longer window lengths are associated with a higher contribution of net entry. We develop a methodology using the calibrated model to adjust the varying window lengths used in the literature. We find that previous studies support our finding that countries with fast-growing GDP per working-age person also tend to have a larger share of aggregate manufacturing productivity growth accounted for by the entry and exit of plants in the FHK decomposition.

We use manufacturing data because this information is more widely available than data for services. For example, we are not aware of any plant-level panel data on the service sector for Chile and Korea. Furthermore, the wider availability of manufacturing data allows us to conduct a survey of the literature to expand the analysis to a greater set of countries.

We consider a country to be experiencing fast growth if the growth rate of GDP per working-age person is at least 4 percent per year. To be clear, we use the terms *fast growth* and *slow growth* only in a descriptive sense to ease exposition. We find it illustrative to categorize countries as relatively fast or slow growing and make comparisons across the groups. In our final analysis, we regard both the GDP per working-age person growth rates and the FHK contribution of entry and

exit as continuous (see Figure 3). In our model, we consider a country to be slow growing if it is on a balanced growth path and to be fast growing if it is in transition to a higher balanced growth path.

### 2.1. Decomposing Changes in Aggregate Productivity Growth

Our aggregate productivity decomposition follows FHK. We define the industry-level productivity of industry $i$ at time $t$, $Z_{it}$, to be

$$\log Z_{it} = \sum_{e \in i_t} s_{eit} \log z_{et} \,, \tag{1}$$

where $s_{eit}$ is the share of plant $e$'s gross output in industry $i$ and $z_{et}$ is the plant's productivity.[3] The industry's productivity change during the *window* $t-1$ to $t$ is

$$\Delta \log Z_{it} = \log Z_{it} - \log Z_{i,t-1} \,. \tag{2}$$

The industry-level change in productivity can be written as the sum of two components,

$$\Delta \log Z_{it} = \Delta \log Z_{it}^{NE} + \Delta \log Z_{it}^{C} \,, \tag{3}$$

where $\Delta \log Z_{it}^{NE}$ is the change in industry-level productivity attributed to the entry and exit of plants and $\Delta \log Z_{it}^{C}$ is the change attributed to continuing plants.[4]

The first component in (3), $\Delta \log Z_{it}^{NE}$, is

$$\Delta \log Z_{it}^{NE} = \underbrace{\sum_{e \in N_{it}} s_{eit} \left( \log z_{et} - \log Z_{i,t-1} \right)}_{\text{entry term}} - \underbrace{\sum_{e \in X_{it}} s_{ei,t-1} \left( \log z_{e,t-1} - \log Z_{i,t-1} \right)}_{\text{exit term}} , \tag{4}$$

where $N_{it}$ is the set of entering plants and $X_{it}$ is the set of exiting plants. We define a plant as *entering* if it is only active at $t$ and *exiting* if it is only active at $t-1$. The first component, the entry term, positively contributes to aggregate productivity growth if entering plants' productivity levels are greater than the initial industry average. The second component, the exit term, positively

[3] The literature on productivity decompositions typically uses gross output weights when TFP is the measure of productivity. See page 318 of Foster, Haltiwanger, and Krizan (2001) for a discussion of this topic.

[4] We follow the literature on productivity decompositions and use a productivity index in logs. The difference in equation (2) can thus be interpreted as a percentage change. See page 318 of Foster, Haltiwanger, and Krizan (2001) where they define the productivity index. Also see equations (2)–(7) in Baily, Hulten, and Campbell (1992).

contributes to aggregate productivity growth if the exiting plants' productivity levels are less than the initial industry average.

The second component in (3), $\Delta \log Z_{it}^{C}$, is

$$\Delta \log Z_{it}^{C} = \underbrace{\sum_{e \in C_{it}} s_{ei,t-1} \Delta \log z_{et}}_{\text{within term}} + \underbrace{\sum_{e \in C_{it}} \left( \log z_{et} - \log Z_{i,t-1} \right) \Delta s_{et}}_{\text{reallocation term}}, \tag{5}$$

where $C_{it}$ is the set of continuing plants. We define a plant as *continuing* if it is active in both $t-1$ and $t$. The first term in (5), the within term, measures productivity growth that is accounted for by changes in the productivity of existing plants. The second term in (5), the reallocation term, measures productivity growth that is due to the reallocation of output shares among existing plants.

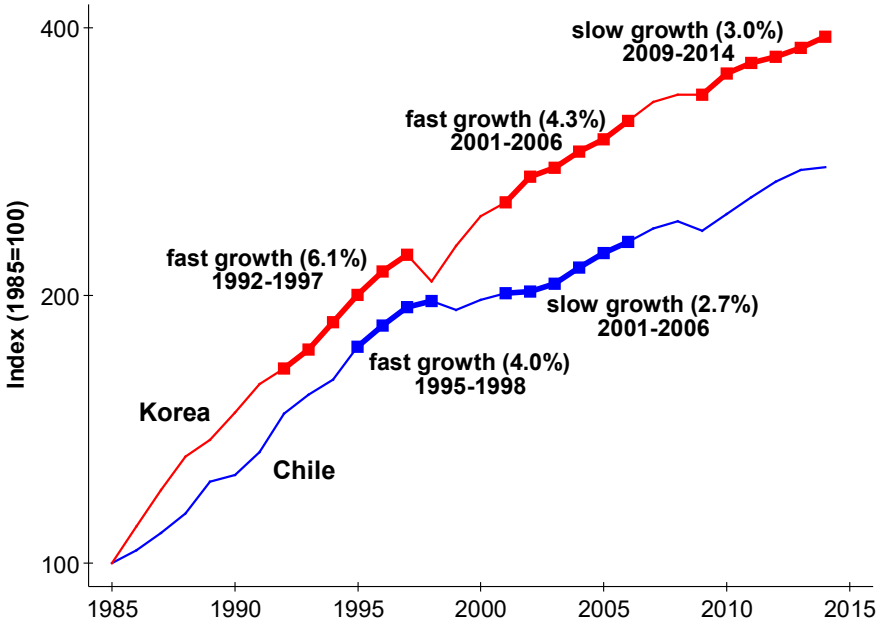
### 2.2. The Role of Net Entry in Chile and Korea

We decompose aggregate manufacturing productivity using the FHK productivity decomposition in two countries that experienced fast growth in the 1990s followed by a slowdown in the 2000s: Chile and Korea. We plot real GDP per working-age person in Chile and Korea in Figure 1. GDP per working-age person in Chile grew at an annualized rate of 4.0 percent during 1995–1998 and, in Korea, GDP per working-age person grew at 6.1 percent during 1992–1997 and 4.3 percent during 2001–2006. GDP growth in Chile slowed to 2.7 percent during 2001–2006 and, in Korea, GDP growth fell to 3.0 percent during 2009–2014. Using plant-level data from these periods, we examine how the importance of net entry in aggregate manufacturing productivity growth in the FHK decomposition evolves in an economy that has fast growth in GDP per working-age person and then experiences a slowdown. The benefit of looking across multiple periods in the same country is that we can avoid cross-country differences and use consistent data sets.

The Chilean data are drawn from the *Encuesta Nacional Industrial Anual* data set provided by the Chilean statistical agency, the Instituto Nacional de Estadística. The panel data set covers all manufacturing establishments in Chile with more than 10 employees for the years 1995–2006. For Korea, we use the *Mining and Manufacturing Surveys* provided by the Korean National Statistical Office. This panel data set covers all manufacturing establishments in Korea with at least 5 workers in the 1992–1997 and 2001–2006 panels and at least 10 workers in the 2009–2014 panel. We drop observations with fewer than 10 employees when using the Korean data to make

the analysis comparable across the two countries and windows. The full details of the data preparation can be found in Appendix A.

**Figure 1. Real GDP per working-age person in Chile and Korea**




The first step in the decomposition is to compute plant-level productivity. For plant $e$ in industry $i$, we assume the production function is

$$\log y_{eit} = \log z_{eit} + \beta_k^i \log k_{eit} + \beta_\ell^i \log \ell_{eit} + \beta_m^i \log m_{eit}, \tag{6}$$

where $y_{eit}$ is gross output, $z_{eit}$ is the plant's productivity, $k_{eit}$ is capital, $\ell_{eit}$ is labor, $m_{eit}$ is intermediate inputs, and $\beta_j^i$ is the industry-specific coefficient of input $j$ in industry $i$.

To define an industry, we use the most disaggregated classification possible. For the Chilean data, this is the 4-digit International Standard Industrial Classification (ISIC) Revision 3. For the Korean data, depending upon the sample window, this is a Korean national system based on the 4-digit ISIC Revision 3 or Revision 4. To get a sense of the level of disaggregation, note that ISIC Revisions 3 and 4 have, respectively, 127 and 137 industries.

We construct measures of real factor inputs for each plant. Gross output, intermediate inputs, and capital are measured in local currencies, and we use price deflators to build the real series. For labor, we use man-years in the Chilean data and number of employees in the Korean data.

Following FHK, the coefficients $\beta_j^i$ are the industry-level factor cost shares, averaged over the beginning and end of each time window.

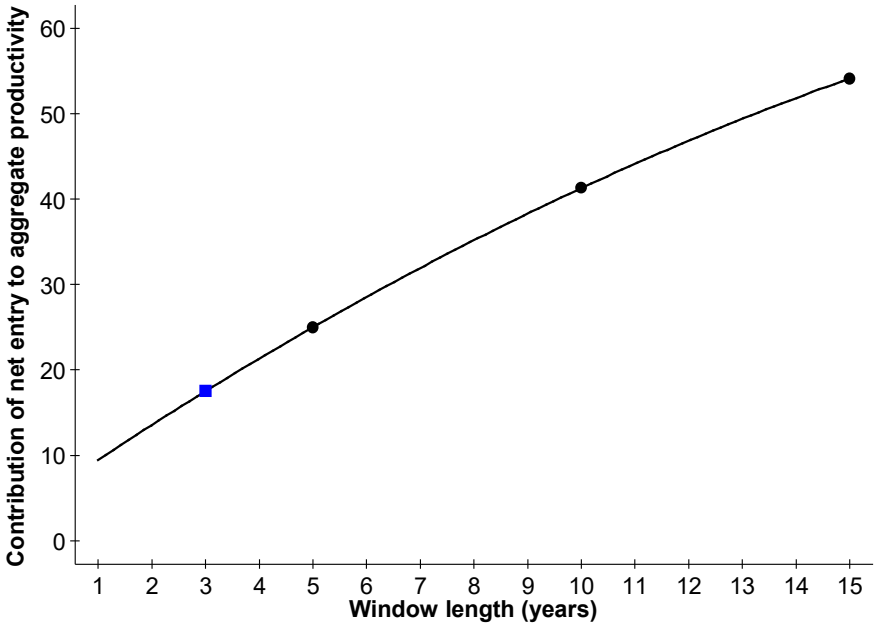
We calculate the industry-level productivity, $\log Z_{it}$, for industry $i$ in each year using (1) and decompose these changes into net entry and continuing terms using (4) and (5). To compute the aggregate manufacturing-wide productivity change, $\Delta \log Z_t$, we weight the productivity change of each industry by the fraction of nominal gross output accounted for by that industry, averaged over the beginning and end of each time window. We follow the same process to compute the aggregate entry, exit, and continuing terms.

Before we compare the results, we must make an adjustment for the varying lengths of the time windows considered. We face the constraint that our data for Chile that cover the fast growth period are three years: The data begin in 1995, and the period of fast growth ends in 1998. Furthermore, in Section 2.5 we describe how we supplement our own work with studies from the literature, which also use windows of varying lengths. The length of the sample window is important because longer sample windows increase the importance of the net entry term in productivity growth.

We use our calibrated model (discussed in Sections 3–7) to convert each measurement into 5-year equivalent windows. To do so, we compute the FHK contribution of net entry generated by the model (on the balanced growth path) using window lengths of 5, 10, and 15 years. The contribution of net entry to aggregate productivity growth in the model is 25.0 percent when measured over a 5-year window, 41.1 percent when measured over a 10-year window, and 53.9 percent when measured over a 15-year window. Using these points, we fit a quadratic equation that relates the importance of net entry to the window length, which we plot in Figure 2. We use the fitted curve to adjust the measurements that do not use 5-year windows.

The contribution of net entry in the FHK decomposition to aggregate manufacturing productivity growth in Chile during the period 1995–1998, for example, is 35.5 percent. To adjust this 3-year measurement to its 5-year equivalent, we divide the model's net entry contribution to aggregate productivity at 5 years (25.0 percent) by the net entry contribution at 3 years (17.6 percent, the square on the curve at 3 years in Figure 2) to arrive at an adjustment factor of 1.42 (=25.0/17.6). The 5-year equivalent Chilean measurement is 50.4 (=1.42×35.5) percent.

**Figure 2. Contribution of net entry under various windows in the model**




We summarize the Chilean and Korean manufacturing productivity decompositions in Table 1. We find that periods with faster GDP growth are accompanied by faster manufacturing productivity growth and larger contributions of net entry to aggregate manufacturing productivity growth in the FHK decomposition. From 1995 to 1998, Chilean manufacturing productivity experienced annual growth of 3.3 percent, compared to 1.9 percent growth during the 2001–2006 period. During the period of fast growth for Chile, net entry accounts for 50.4 percent of aggregate manufacturing productivity growth, whereas it accounts for only 22.8 percent during the period with slower growth. In Korea, the manufacturing sector experienced annual productivity growth of 3.6 percent during 1992–1997 and 3.3 percent during 2001–2006, compared to 1.5 percent during 2009–2014. During the periods of fast growth, net entry accounts for 48.0 percent of aggregate manufacturing productivity growth in 1992–1997 and 37.3 percent in 2001–2006, compared to only 25.1 percent in 2009–2014.

**Table 1: Contribution of net entry in manufacturing productivity decompositions**

| Period | Country | Real GDP per working-age person annual growth (percent) | Aggregate manufacturing productivity annual growth (percent) | Contribution of net entry (percent) |
|---|---|---|---|---|
| 1995–1998 | Chile | 4.0 | 3.3 | 50.4* |
| 2001–2006 | Chile | 2.7 | 1.9 | 22.8 |
| 1992–1997 | Korea | 6.1 | 3.6 | 48.0 |
| 2001–2006 | Korea | 4.3 | 3.3 | 37.3 |
| 2009–2014 | Korea | 3.0 | 1.5 | 25.1 |

*Measurements adjusted to be comparable with the results from the 5-year windows.

### 2.3. Entering and Exiting Cohorts: Relative Productivity and Market Shares

In this section, we investigate whether the results from the previous section are driven by changes in the productivity of entering and exiting plants or in their market shares by decomposing the FHK entering and exit terms. First, we calculate a measure of the relative productivity of entering plants. For each industry we find the difference between the weighted average productivity of entering plants and the industry-level productivity from the beginning of the window. We similarly calculate the difference between the weighted average productivity of exiting plants and the industry-level productivity at the beginning of the window. For the market shares, we use the market share of entering plants at the end of the window and the market share of exiting plants at the beginning of the window. We then aggregate these measures using the industry-level weights described in Appendix C.1.

The results are reported in Table 2. We find that in both Chile and Korea, periods of fast growth are accompanied by increases in the relative productivity of entering plants. For example, during the 2001–2006 window in Korea, entering plants were 7.3 percent more productive than the average industry-level productivity at the beginning of the window. On the other hand, in the 2009–2014 window, entering plants were 2.4 percent less productive. We similarly find that periods of fast growth tend to be accompanied by the exit of relatively unproductive plants. This pattern is true for the case of Chile and is also true on average for Korea (comparing the slow growth window with the average of the two fast growth windows). In the case of Korea, for example, during the 2001–2006 window, exiting plants were 18.9 percent less productive than the average industry-level productivity at the beginning of the window, whereas, in the 2009–2014 window, they were

10.5 percent less productive. Furthermore, we do not find a consistent pattern across Chile and Korea with respect to the market share of entering and exiting plants during periods of fast and slow growth. In Appendix C.2, we find that the entry and exit rates of plants exhibit patterns similar to those of the market shares reported in Table 2.[5]

**Table 2: Relative productivity and market share of entering and exiting plants**

| Period | Aggregate manufacturing productivity growth (percent) | Relative productivity of entrants (percent) | Market share of entrants | Relative productivity of exiters (percent) | Market share of exiters |
|---|---|---|---|---|---|
| Chile | | | | | |
| 1995–1998* | 17.6 | 28.1 | 0.24 | −5.7 | 0.20 |
| 2001–2006 | 9.8 | 6.8 | 0.36 | 0.9 | 0.23 |
| Korea | | | | | |
| 1992–1997 | 19.3 | 15.0 | 0.38 | −10.5 | 0.35 |
| 2001–2006 | 17.6 | 7.3 | 0.27 | −18.9 | 0.24 |
| 2009–2014 | 7.7 | −2.4 | 0.27 | −10.5 | 0.24 |

*Measurements adjusted to be comparable with the results from the 5-year windows.

Note: The measures of relative productivity compare the productivity of entrants and exiters to the industry-level productivity of the beginning of the window.

It is useful to notice that columns 3–6 in Table 2 are inputs into the calculation of the contribution of net entry. In particular, the net entry contribution can be calculated as the product of the relative productivity of entering plants and their market shares (in the case of the 2001–2006 window for Chile this would be 6.8×0.36) subtracted by the product of the relative productivity of exiting plants and their market shares (0.9×0.23), which is then divided by the aggregate productivity growth (9.8). In the case of Chile this calculation gives 23 percent, which is consistent with the results in Table 1. See Appendix C.1 for further details.

[5] In Appendix C, we report additional statistics for the windows we study, such as the entry and exit rate of plants, incumbent productivity growth, and the productivity of entrants and exiters relative to the productivity of incumbents.

### 2.4. Robustness Exercises and Additional Discussions

In Appendix B, we conduct a series of robustness exercises. First, we consider alternative productivity decompositions as described in Griliches and Regev (1995) and Melitz and Polanec (2015) (see Appendix B.1). Our finding that net entry is a more important contributor to aggregate manufacturing productivity during periods of fast growth in GDP per working-age person is robust to these alternative methods. In Appendix B.2, we also show that this result is robust to using the Wooldridge (2009) extension of the Levinsohn and Petrin (2003) methodology to estimate the production function. It is also robust to using value added as weights, as opposed to gross output weights (see Appendix B.3).

We also consider an additional robustness exercise in which we use constant industry weights to assess whether our results are driven by the changing composition of industries rather than by within-industry dynamics (see Appendix B.3). Suppose, for example, that some industries have higher shares of productivity growth that are accounted for by entry and exit and that these shares are constant over time. If the industries with higher shares of growth due to entry and exit have increasing shares of output during rapid growth periods, this could account for the empirical regularity we identify. The results of our robustness exercise show, however, that the empirical regularity remains after we use constant industry weights across windows.

The analysis above only considers plants that have 10 or more employees. For this reason, we conduct robustness exercises to investigate whether this limitation affects our results (see Appendix B.4). First, we recompute the contribution of net entry for the windows 1992–1997 and 2001–2006 for Korea. For these time windows, the data include all plants with 5 or more employees. We did not use plants with 5–9 employees in the baseline case in order to ensure comparability with the 2009–2014 window for Korea and the two windows from Chile for which the data set only covers plants with 10 or more employees. Second, we recompute the contribution of net entry for all windows except that we only use data for plants with 15 or more employees. The baseline results do not change significantly with these different cutoffs.

We next investigate whether higher productivity growth is correlated with higher contributions of net entry at the industry level. In Appendix B.5, we estimate regressions in which the contribution of net entry is the dependent variable and industry productivity growth is the independent variable. We also include window and industry fixed effects in these regressions. In the case of Chile, the estimated coefficients are positive, although they are not statistically significant. In the case of Korea, the estimated coefficients are positive and statistically significant in some specifications. This evidence suggests that, especially in the case of Korea, changes in productivity growth rates within industry across time are associated with higher contributions of net entry. To give a sense of the magnitude for the case of Korea, an increase in industry-level productivity of 5 percentage points (annualized), equivalent to an increase of one standard deviation, is correlated with an increase of 25 percentage points in the contribution of net entry.

Finally, we discuss whether our results could be driven by structural transformation. For example, a rapidly expanding manufacturing sector during the periods of fast growth could lead to an increase in the entry of new plants. We find, however, that Chile and Korea do not have rapidly changing manufacturing sectors during the periods we study. For example, in the case of Chile, the average value added accounted for by manufacturing is 19.9 percent during 1995–1998 and 17.8 percent during 2001–2006. In the case of Korea, the average value added accounted for by manufacturing is 27.3 percent during 1995–1998, 27.8 percent during 2001–2006, and 29.9 percent during 2009–2014. Moreover, of the five windows we study, the only significant change in manufacturing's value added share is the 2001–2006 window in Chile, during which the share declines from 20.7 percent to 14.0 percent. However, we do not believe that the lower contribution of entry and exit is due to the changes in sectoral composition. The reason is that the market share of entrants and exiters does not move systematically with productivity growth, as seen in Table 2.

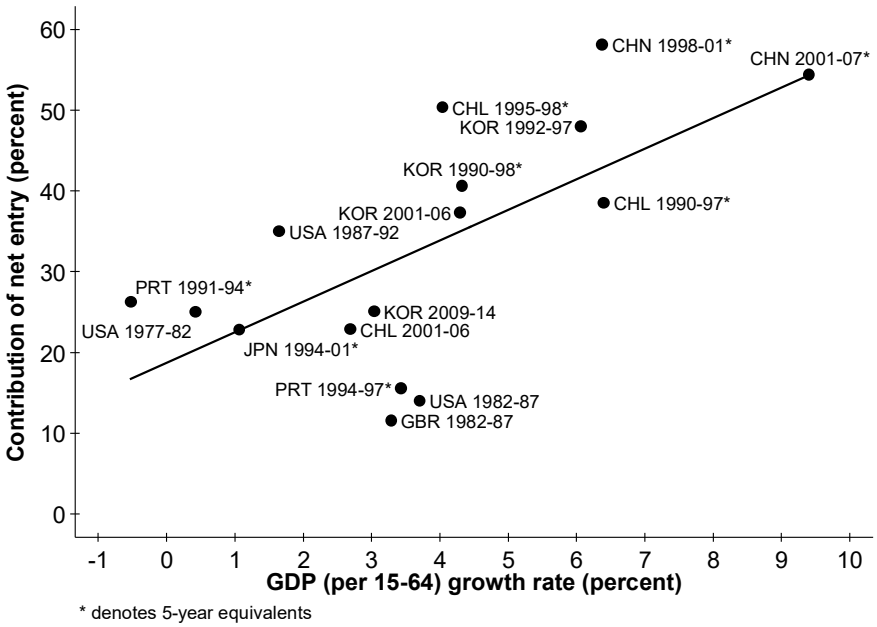
### 2.5. The Role of Net Entry in the Cross Section

In Section 2.2 we studied the contribution of net entry in the FHK decomposition to aggregate manufacturing productivity growth in Chile and Korea, countries that experienced both fast growth in GDP per working-age person and a subsequent slowdown. This approach is ideal because we eliminate problems that might arise from cross-country differences. We would like to study the determinants of aggregate manufacturing productivity growth in as many countries as possible, but access to plant-level data constrains the set of countries we are able to consider. Fortunately,

several researchers have used the same methodology we describe in Section 2.1 to study countries that are growing relatively slowly (Japan, Portugal, the United Kingdom, and the United States) and countries that are growing relatively fast (Chile, China, and Korea). As mentioned before, we consider a country to be growing relatively fast if the growth rate of GDP per working-age person is at least 4 percent per year. These studies are not focused on the questions we ask here, but their use of TFP as the measure of productivity, gross output production functions, gross output as weights, manufacturing data, and the FHK decomposition makes their calculations comparable to ours for Chile and Korea.

Table 3 summarizes our findings as well as those in the literature. The sixth column in the table contains the contributions of net entry to aggregate manufacturing productivity growth in the FHK decomposition as reported in the studies, and the seventh column contains the adjusted 5-year equivalents. In the first panel of Table 3, we gather results from countries with relatively slow growth rates of GDP per working-age person. In this set of countries, the contribution of net entry ranges from 12 percent to 35 percent, with an average of 22 percent. In the second panel of Table 3, we gather the results from countries with relatively high growth rates of GDP per working-age person. In this set of countries, the contribution of net entry to aggregate manufacturing productivity growth ranges between 37 and 58 percent, with an average of 47 percent.

**Figure 3: The contribution of net entry and GDP growth**



In Figure 3, we summarize our findings. On the vertical axis, we plot the contribution of net entry to aggregate manufacturing productivity growth in the FHK decomposition, and on the horizontal axis, we plot the economy's growth rate of GDP per working-age person. The figure shows a clear, positive correlation: The net entry of plants is more important for aggregate manufacturing productivity growth during periods of fast GDP per working-age person growth. Combining our results with those of studies from the literature yields a more complete picture of the relationship between GDP per working-age person growth and the contribution of net entry to aggregate manufacturing productivity growth. Note that there is also a positive relationship between aggregate productivity growth in manufacturing and net entry. This is not a surprise, since the correlation between growth rates of GDP per working-age person and growth rates of aggregate manufacturing productivity is 0.73, and if we remove one outlier observation (Portugal 1991–1994), this correlation rises to 0.88.

**Table 3: Productivity decompositions**

| Country | Period | GDP/WAP growth rate | Aggregate manufacturing productivity growth rate | Window | Net entry contribution | Net entry contribution, 5-year equiv. | Source |
|---|---|---|---|---|---|---|---|
| Japan | 1994–2001 | 1.1 | 0.3 | 7 years | 29 | 23 | Fukao and Kwon (2006) |
| Portugal | 1991–1994 | -0.5 | 3.0 | 3 years | 19 | 26 | Carreira and Teixeira (2008) |
| Portugal | 1994–1997 | 3.4 | 2.5 | 3 years | 11 | 16 | Carreira and Teixeira (2008) |
| U.K. | 1982–1987 | 3.3 | 2.9 | 5 years | 12 | 12 | Disney et al. (2003) |
| United States | 1977–1982 | 0.4 | 0.5 | 5 years | 25 | 25 | Foster et al. (2001) |
| United States | 1982–1987 | 3.7 | 1.4 | 5 years | 14 | 14 | Foster et al. (2001) |
| United States | 1987–1992 | 1.6 | 0.7 | 5 years | 35 | 35 | Foster et al. (2001) |
| Chile | 2001–2006 | 2.7 | 1.9 | 5 years | 23 | 23 | Authors' calculations |
| Korea | 2009–2014 | 3.0 | 1.5 | 5 years | 25 | 25 | Authors' calculations |
| **Average** | | **2.1** | **1.6** | | | **22** | |
| China | 1998–2001 | 6.4 | 3.2 | 3 years | 41 | 58 | Brandt et al. (2012) |
| China | 2001–2007 | 9.4 | 4.5 | 6 years | 62 | 54 | Brandt et al. (2012) |
| Chile | 1990–1997 | 6.4 | 3.4 | 7 years | 49 | 39 | Bergoeing and Repetto (2006) |
| Korea | 1990–1998 | 4.3 | 3.5 | 8 years | 57 | 41 | Ahn et al. (2004) |
| Chile | 1995–1998 | 4.0 | 3.3 | 3 years | 36 | 50 | Authors' calculations |
| Korea | 1992–1997 | 6.1 | 3.6 | 5 years | 48 | 48 | Authors' calculations |
| Korea | 2001–2006 | 4.3 | 3.3 | 5 years | 37 | 37 | Authors' calculations |
| **Average** | | **5.8** | **3.5** | | | **47** | |

Notes: The third column reports annual growth rates of real GDP per working-age person (in percent) over the period of study. The fourth column reports the aggregate manufacturing productivity growth (in percent) in the manufacturing sector as described in (2). The fifth column reports the sample window's length. The sixth column reports the contribution of net entry (in percent) during the sample window using the decomposition described in (3). The seventh column reports the net entry contribution (in percent) normalized to 5-year sample windows. The eighth column reports the source of the information. All studies use TFP as the measure of productivity, the gross output production function, gross output shares as weights, and manufacturing data. All studies use plants except for Brandt et al. (2012), Fukao and Kwon (2006), and Carreira and Teixeira (2008), which use firms.

## 3. Model

In this section, we develop a simple dynamic general equilibrium model of firm entry and exit based on Hopenhayn (1992). We model a continuum of firms in a closed economy. Openness was undoubtedly important in the growth experiences of Chile and Korea. In this paper, however, we focus on the simplest possible model so that we can understand how economic forces manifest in the FHK decomposition. Furthermore, when we look at the reforms implemented in Chile and Korea during the episodes we study, we do not find major trade reforms. In the conclusion, we discuss how our model can be extended to an open economy model.

Firms are heterogeneous in their marginal efficiencies and produce a single good in a perfectly competitive market. Time is discrete and there is no aggregate uncertainty. As in Parente and Prescott (1994) and Kehoe and Prescott (2002), all countries grow at the same rate when they are on the balanced growth path, but the level of the balanced growth path depends on the distortions in the economy. We incorporate three distortions, a portion of which we interpret as being the result of government policy. First, potential firms face entry costs. Second, new firms face barriers that prevent them from adopting the most efficient technology. Third, there is a fixed continuation cost that firms must pay to operate each period. When the policy-induced barriers are reduced, the economy transits to a higher balanced growth path.

The model has three key features. First, the distribution from which potential entrants draw their efficiencies exogenously improves each period. Second, the efficiency of existing firms improves both through an exogenous process and through spillovers from the rest of the economy. Finally, firm entry and exit are endogenous, although we also allow for exogenous exit.

In terms of linking the empirical work and the model, we make two points. First, firms in the model are heterogeneous in their efficiencies. These efficiencies are not the same as the productivity that we measure in the data. When we decompose aggregate productivity growth in the model, we must compute a firm's productivity using the same process described in Section 2.2. Second, our plant-level data do not distinguish between single-plant and multi-plant firms. Given this lack of data, we treat a plant in the data as being equivalent to a firm in our model. One concern may be whether the entry of plants is due to the entry of new firms or the creation of new plants by continuing firms. We find that in the case of the United States, however, the bulk of new plants are created by new firms: Statistics from the U.S. Census Longitudinal Business Database indicate

that 76 percent of new establishments are created by firms that are less than 4 years old (average 1980–2000).

### 3.1. Households

The representative household inelastically supplies one unit of labor to firms and chooses consumption and bond holdings to solve

$$\begin{aligned} \max \quad & \sum_{t=0}^{\infty} \beta^t \log C_t \\ \text{s.t.} \quad & P_t C_t + q_{t+1} B_{t+1} = w_t + B_t + D_t \\ & C_t \geq 0, \text{ no Ponzi schemes, } B_0 \text{ given,} \end{aligned} \tag{7}$$

where $\beta$ is the discount factor, $C_t$ is household consumption, $P_t$ is the price of the good, $q_{t+1}$ is the price of the one-period bond, $B_{t+1}$ are the holdings of one-period bonds purchased by the household, $w_t$ is the wage, and $D_t$ are aggregate dividends paid by firms. We normalize $P_t = 1$ for all $t$.

### 3.2. Producers

In each period $t$, potential entrants pay a fixed entry cost, $\kappa_t$, to draw a marginal efficiency, $x$, from the distribution, $F_t(x)$, whose mean grows exogenously by $g_e > 1$. This entry cost is paid by the household, entitling it to the future dividends of firms that operate. After observing their efficiencies, potential entrants choose whether to operate. We refer to potential entrants that draw a high enough efficiency to justify operating as successful entrants. Potential entrants that do not draw a high enough efficiency are failed entrants. Firms that operate may exit for exogenous reasons (with probability $\delta$) or may endogenously exit when the firm's value is negative.

We first characterize the profit maximization problem of a firm that has chosen to operate. A firm with efficiency $x$ uses a decreasing returns to scale production technology,

$$y = x\ell^{\alpha}, \tag{8}$$

where $\ell$ is the amount of labor used by the firm and $0 < \alpha < 1$. Conditional on operating, firms hire labor to maximize dividends, $d_t(x)$,

$$d_t(x) = \max_{\ell} x\ell^{\alpha} - w_t - f_t, \tag{9}$$

where $f_t$ is the fixed continuation cost, which is denominated in units of the consumption good. The solution to (9) is given by

$$\ell_t(x) = \left( \frac{\alpha x}{w_t} \right)^{\frac{1}{1-\alpha}}. \tag{10}$$

Notice that labor demand is increasing in the efficiency of the firm. An important mechanism in our model is the increase in the wage that results from an inflow of relatively productive new firms.

At the beginning of each period, an operating firm chooses whether to produce in the current period or to exit. If the firm chooses to exit, its dividends are zero and the firm cannot re-enter in subsequent periods. The value of a firm with efficiency $x$ is

$$V_t(x) = \max\{d_t(x) + q_{t+1}(1-\delta)V_{t+1}(xg_{c,t+1}), 0\}, \tag{11}$$

where $g_{c,t+1}$ is the continuing firm's efficiency growth factor from $t$ to $t+1$.[6] This efficiency growth factor is characterized by

$$g_{ct} = \overline{g} g_t^{\varepsilon}, \tag{12}$$

where $\overline{g}$ is a constant, $g_t$ is the growth factor from $t-1$ to $t$ of the unweighted mean efficiency of all firms that operate in each period, and $\varepsilon$ measures the degree of spillovers from the aggregate economy to the firm. These spillovers are not important for our theory, but they are important for our quantitative results. We assume that $\overline{g} < g_e^{1-\varepsilon}$, which ensures endogenous exit on the balanced growth path.

Since $d_t(x)$ is increasing in $x$, $V_t(x)$ is also increasing in $x$, and firms operate if and only if they have an efficiency above the cutoff threshold, $\hat{x}_t$, which is characterized by

$$V_t(\hat{x}_t) = 0. \tag{13}$$

It is useful to define the minimum efficiency of firms in a cohort of age $j$, $\hat{x}_{jt}$. For all firms age $j=1$, we have that $\hat{x}_{1t} = \hat{x}_t$ since firms only enter if the firm's value is positive. For all firms age $j \geq 2$, $\hat{x}_{jt}$ is characterized by

[6] In Appendix I, we consider an alternative model in which continuing firms are subject to idiosyncratic efficiency growth shocks.

$$\hat{x}_{jt} = \max\left\{\hat{x}_t, \hat{x}_{j-1,t-1} g_{ct}\right\}. \tag{14}$$

If there are firms in a cohort that choose to exit, then $\hat{x}_{jt} = \hat{x}_t$. If no firms in the cohort choose to exit, then the minimum efficiency evolves with the efficiency of the least-efficient operating firm adjusted for efficiency growth, $\hat{x}_{jt} = \hat{x}_{j-1,t-1} g_{ct}$.

### 3.3. Entry

Upon paying the fixed entry cost, $\kappa_t$, a potential entrant draws its efficiency, $x$, from a Pareto distribution,

$$F_t(x) = 1 - \left(\frac{\varphi x}{g_e^t}\right)^{-\gamma}, \tag{15}$$

for $x \geq g_e^t / \varphi$. The parameter $\gamma$ governs the shape of the efficiency distribution. We assume that $\gamma(1-\alpha) > 1$, which is necessary for the distribution of profits to have a finite mean. In the spirit of Parente and Prescott (1994), the parameter $\varphi$ characterizes the barriers to technology adoption faced by potential entrants. When $\varphi > 1$, potential entrants draw their efficiencies from a distribution that is stochastically dominated by the frontier efficiency distribution. The mean of (15) is proportional to $g_e^t / \varphi$, so increasing the barriers to technology adoption lowers the mean efficiency of potential entrants.

We assume that both the entry cost, $\kappa_t = \kappa g_e^t$, and the fixed continuation cost, $f_t = f g_e^t$, grow at the same rate as the potential entrant's average efficiency. In the next section, we show that these assumptions imply that the fixed costs incurred are a constant share of output per capita and thus ensure the existence of a balanced growth path. Our formulation is similar to that of Acemoglu, Aghion, and Zilibotti (2003), who assume that fixed costs are proportional to the frontier technology. In Appendix F, we consider an alternative model in which fixed costs are denominated in units of labor, which has the same property. We assume that the cost of entry, $\kappa = \kappa^T\left(1+\tau^\kappa\right)$, is composed of two parts. The first, $\kappa^T$, is technological and is common across all countries. The second, $\tau^k \geq 0$, is the result of policy. The fixed continuation cost is defined analogously as $f = f^T(1+\tau^f)$.

The mass of potential entrants, $\mu_t$, is determined by the free-entry condition,

$$E_x\left[V_t(x)\right]=\kappa_t. \tag{16}$$

At time $t$, the mass of firms of age $j$ in operation, $\eta_{jt}$, is

$$\eta_{jt}=\mu_{t+1-j}\left(1-\delta\right)^{j-1}\left(1-F_{t+1-j}\left(\hat{x}_{jt}/\tilde{g}_{jt}\right)\right), \tag{17}$$

where $\tilde{g}_{jt}=\prod_{s=1}^{j-1}g_{c,t-s+1}$ is a factor that converts the time-$t$ efficiency of an operating firm to its initial efficiency, which is needed to index the efficiency distribution. The total mass of operating firms is

$$\eta_t=\sum_{i=1}^{\infty}\eta_{it}\,. \tag{18}$$

### 3.4. Equilibrium

The economy's initial conditions are households' bond holdings $B_0$ and the measures of firms operating in period zero for ages $j=1,...,\infty$, given by $\{\mu_{t-j+1},\hat{x}_{j0},g_{c,t-j+1}\}_{j=1}^{\infty}$. We also need to define the distributions of efficiencies from which these existing firms were drawn. These distributions are analogous to those for firms born in period zero and later,

$$F_{1-j}(x)=1-\left(\frac{\varphi x}{g_e^{j-1}}\right)^{-\gamma},\ \ x\geq g_e^{j-1}/\varphi, \tag{19}$$

for $j\geq 1$.

**Definition:** Given the initial conditions, an *equilibrium* is sequences of minimum efficiencies $\{\hat{x}_{jt}\}_{t=0}^{\infty}$ and firm allocations, $\{y_t(x),\ell_t(x)\}_{t=0}^{\infty},x\geq g_e^{t-j+1}/\varphi$, for $j=1,...,\infty$, masses of potential entrants $\{\mu_t\}_{t=0}^{\infty}$, masses of operating firms $\{\eta_t\}_{t=0}^{\infty}$, prices $\{w_t,q_{t+1}\}_{t=0}^{\infty}$, aggregate dividends and output $\{D_t,Y_t\}_{t=0}^{\infty}$, and household consumption and bond holdings $\{\mathrm{C}_t,B_{t+1}\}_{t=0}^{\infty}$, such that, for all $t\geq 0$:

1. Given $\{w_t,D_t,q_{t+1}\}_{t=0}^{\infty}$, the household chooses $\{C_t,B_{t+1}\}_{t=0}^{\infty}$ to solve (7).
2. Given $\{w_t\}_{t=0}^{\infty}$, the firm with efficiency $x\geq g_e^{t-j+1}/\varphi$ chooses $\{\ell_t(x)\}_{t=0}^{\infty}$ to solve (9).
3. The mass of potential entrants is characterized by the free-entry condition in (16).

4. The mass of operating firms is characterized by (17) and (18).
5. The labor market clears,

$$1=\sum_{j=1}^{\infty}\left[\mu_{t+j-1}(1-\delta)^{j-1}\int_{\hat{x}_{jt}}^{\infty}\ell_t(x)dF_{t+j-1}\left(x/\tilde{g}_{jt}\right)\right]. \tag{20}$$

6. Entry-exit thresholds $\{\hat{x}_{jt}\}_{t=0}^{\infty}$ satisfy conditions (13) and (14) for all $j=1,...,\infty$.
7. The bond market clears, $B_{t+1}=0$.
8. The goods market clears,

$$C_t+\eta_t f_t+\mu_t\kappa_t=Y_t=\sum_{j=1}^{\infty}\left[\mu_{t+j-1}(1-\delta)^{j-1}\int_{\hat{x}_{jt}}^{\infty}x\ell_t(x)^{\alpha}\,dF_{t-j+1}\left(x/\tilde{g}_{jt}\right)\right]. \tag{21}$$

9. Aggregate dividends are the sum of firm dividends less entry costs,

$$D_t=\sum_{j=1}^{\infty}\left[\mu_{t+j-1}(1-\delta)^{j-1}\int_{\hat{x}_{jt}}^{\infty}d_t(x)dF_{t-j+1}\left(x/\tilde{g}_{jt}\right)\right]-\mu_t\kappa_t. \tag{22}$$

## 4. Balanced Growth Path

In this section, we define a balanced growth path for the model described in Section 3 and prove its existence. We also conduct comparative statics exercises to show how the output level on the balanced growth path depends on entry costs, fixed continuation costs, and barriers to technology adoption.

### 4.1. Definition and Proof of Existence

**Definition:** A *balanced growth path* is an equilibrium, for the appropriate initial conditions, such that the sequences of wages, output, consumption, dividends, and entry-exit thresholds grow at rate $g_e-1$, and bond prices, measures of potential entrants, and measures of operating firms are constant. On the balanced growth path, for all $t\geq 0$ and $j\geq 1$,

$$\frac{w_{t+1}}{w_t}=\frac{Y_{t+1}}{Y_t}=\frac{C_{t+1}}{C_t}=\frac{D_{t+1}}{D_t}=\frac{\hat{x}_{j,t+1}}{\hat{x}_{jt}}=g_e, \tag{23}$$

and $q_{t+1}=\beta/g_e$, $\mu_t=\mu$, $\eta_t=\eta$.

**Proposition 1.** *A balanced growth path exists.*

*Proof:* On the balanced growth path, the profitability of a firm declines over time because of the continual entry of firms with higher efficiencies. Thus, once a firm becomes unprofitable, it exits, which implies that the cutoff efficiency is characterized by the static zero-profit condition, $d_t(\hat{x}_t) = 0$. Furthermore, firms of every age endogenously exit each period, so $\hat{x}_{jt} = \hat{x}_t$ for all $j \geq 1$. The mass of operating firms is

$$\eta(\kappa, f, \varphi) = \frac{\gamma(1-\alpha)-1}{\lambda(\kappa, f, \varphi) f \gamma}, \tag{24}$$

where $\lambda(\kappa, f, \varphi) = g_e^t / Y_t(\kappa, f, \varphi)$, which is constant on the balanced growth path. Thus, the entry cost is a constant share of output per capita,

$$\lambda(\kappa, f, \varphi)\kappa = \frac{\kappa_t}{Y_t(\kappa, f, \varphi)}. \tag{25}$$

An analogous argument proves that the fixed continuation cost is also a constant share of output per capita. The mass of potential entrants is

$$\mu(\kappa, f, \varphi) = \frac{\xi}{\lambda(\kappa, f, \varphi)\kappa\gamma\omega}, \tag{26}$$

where $\xi$ and $\omega$ are positive constants. The cutoff efficiency to operate is given by

$$\hat{x}_t(\kappa, f, \varphi) = \frac{g_e^t}{\varphi}\left[\omega \frac{\mu(\kappa, f, \varphi)}{\eta(\kappa, f, \varphi)}\right]^{\frac{1}{\gamma}}, \tag{27}$$

which, because $\mu(\kappa, f, \varphi)$ and $\lambda(\kappa, f, \varphi)$ are constants, grows at rate $g_e - 1$.

Since the cutoffs grow at rate $g_e - 1$, the other aggregate variables related to income also grow at rate $g_e - 1$,

$$Y_t(\kappa, f, \varphi) = \left[\frac{\gamma(1-\alpha)}{\gamma(1-\alpha)-1}\eta(\kappa, f, \varphi)\right]^{1-\alpha} \hat{x}_t(\kappa, f, \varphi), \tag{28}$$

$$w_t(\kappa, f, \varphi) = \alpha Y_t(\kappa, f, \varphi), \tag{29}$$

$$D_t(\kappa, f, \varphi) = \frac{\omega - \xi}{\gamma\omega} Y_t(\kappa, f, \varphi). \tag{30}$$

From the household's first-order conditions, the bond price is given by $q_{t+1} = \beta / g_e$. Finally,

$$\lambda(\kappa, f, \varphi) = f^{\frac{\gamma(1-\alpha)-1}{\alpha\gamma}} \varphi^{\frac{1}{\alpha}} \kappa^{\frac{1}{\alpha\gamma}} \nu, \tag{31}$$

where $\nu$ is a positive constant. Appendix D contains further details. □

How does the improving efficiency distribution of new firms generate growth? Each entering cohort of firms has a higher average efficiency than the previous cohort. These more efficient firms increase the demand for labor, as seen in (10), increasing the wage and the efficiency needed to operate. Thus, inefficient firms from previous generations are replaced by more efficient firms.

The balanced growth path has the interesting feature that, although there is efficiency growth among continuing firms, long-run output growth in the economy is solely determined by the improving efficiency of potential entrants, $g_e$. This is due to endogenous selection: Because inefficient firms exit, the remaining incumbents are more efficient than the previous cohort of incumbents by a factor of $g_e$. Furthermore, if two economies have the same $g_e$, they grow at the same rate, regardless of their entry costs, barriers to technology adoption, or fixed continuation costs. The cross-country differences in these parameters map into differences in the level of output on the balanced growth path.

### 4.2. Comparative Statics

We conduct comparative statics to understand the mechanisms through which lowering distortions raises output. Three points are worth mentioning. First, as seen in (28), income can rise because of an increase in the mass of operating firms or an increase in the efficiency cutoffs. Second, each policy change has both direct and indirect effects. The indirect effect is summarized by changes in $\lambda(\kappa, f, \varphi)$, which relates the size of fixed costs to output, as shown in (25). Finally, it is useful to know that $\xi$, $\omega$, and $\nu$ are positive constants that do not depend on $\kappa$, $\varphi$, or $f$, whereas $\lambda(\kappa, f, \varphi)$ is increasing in each of its arguments.

We now show that each reform operates through different channels. We focus on the direct effect and thus hold $\lambda(\kappa, f, \varphi)$ fixed. First, consider an economy that decreases its entry cost, $\kappa$. Lower entry costs lead to an increase in the mass of potential entrants in (26), which increases the cutoff efficiency in (27). The increase in the cutoff efficiency results in an increase in output in

(28). Second, when a country lowers the barriers to technology adoption, $\varphi$, there is an increase in the efficiency threshold in (27), which increases output. In contrast to the decline in entry costs, the mass of potential entrants remains unchanged. Rather, efficiency thresholds increase because firms have access to a better efficiency distribution. Finally, consider a reduction in the fixed continuation cost, $f$. Equation (24) shows that this leads to an increase in the mass of operating firms. There are two opposing effects. On the one hand, the increase in the mass of operating firms lowers the efficiency cutoffs in (27), which lowers output in (28). On the other hand, the increase in the mass of operating firms raises output in (28). We can show that the latter effect dominates. Thus, lowering fixed continuation costs raises output and, in contrast to reforms to entry costs and barriers to technology adoption, lowers the efficiency cutoffs.

All of the reforms we discuss above have the same indirect effect through changes in $\lambda(\kappa, f, \varphi)$. A reduction in entry costs, barriers to technology adoption, or fixed continuation costs has the indirect effect of decreasing the fixed costs relative to output. This increases both the mass of operating firms in (24) and the mass of potential entrants in (26). The increase in the mass of operating firms results in an increase in output in (28). Note that these indirect effects have no impact on the efficiency thresholds. To see this, substitute (24) and (26) into (27).

## 5. Measurement

We need to define the capital stock of firms in the model so that we can measure productivity in the model in the same way we measure it in the data. When a new firm is created, the firm invests $\kappa_t + f_t$ units of consumption to create $\kappa_t + f_t$ units of capital. We assume that, in each period, the capital stock depreciates by $f_t - (\kappa_{t+1} - \kappa_t)$ and, if the firm continues to operate, it invests $f_{t+1}$. This implies that the firm's capital stock in $t+1$ is

$$k_{t+1} = \kappa_t + f_t - \left[f_t - (\kappa_{t+1} - \kappa_t)\right] + f_{t+1} = \kappa_{t+1} + f_{t+1}. \tag{32}$$

This formulation implies that all firms have the same capital stock, which keeps the productivity analysis tractable. The complete details are available in Appendix E. In Appendix G, we also report the quantitative results from an alternative model in which labor is a composite of variable labor and variable capital. We find that the results are qualitatively similar but the contribution of entry and exit to aggregate productivity growth during periods of fast GDP growth is larger.

The productivity $z$ of a firm with efficiency $x$ is measured as

$$\log\left[z_t(x)\right] = \log\left[y_t(x)\right] - \alpha_{\ell t}\log\left[\ell_t(x)\right] - \alpha_{kt}\log\left(k_t\right), \tag{33}$$

where $\alpha_{\ell t} = w_t / Y_t$ is the labor share, $\alpha_{kt} = R_t K_t / Y_t$ is the capital share, $R_t = 1/q_t - 1 + \delta_{kt}$ is the rental rate of capital, $K_t$ is the aggregate capital stock, and $\delta_{kt}$ is the aggregate depreciation rate. Note that $P_t$ has been normalized to 1 in our model, which implies that $y_t(x) = P_t y_t(x)$. This is identical to the way productivities and factor shares are computed in Section 2, with the exception that we do not have intermediate goods in our model. In Appendix E, we provide the derivation of the aggregate depreciation rate, which is constant on the balanced growth path but not in the transition. Once we measure firm productivity, we calculate aggregate productivity and the FHK decompositions using the model-generated data as described in (4) and (5).

It is useful to discuss how measured productivity is related to efficiency in the model. We substitute the production function in (8) into (33) and use the fact that $\alpha_{\ell t} = \alpha$ to obtain

$$\log\left[z_t(x)\right] = \log x - \alpha_{kt}\log\left(\kappa_t + f_t\right). \tag{34}$$

Thus, measured productivity and efficiency are tightly linked, the only difference being the last term, which is common across all firms. It follows that, on the balanced growth path, the aggregate productivity growth rate is smaller than the GDP growth rate, $g_e$, because of the growth of capital. In particular, we have that

$$\Delta \log Z_{it} = \left(1 - \alpha_k\right)\log g_e. \tag{35}$$

## 6. Analytical Characterizations of the FHK Decomposition

A strength of our modeling approach is that we can recover analytic expressions for the FHK productivity decomposition on the balanced growth path. This allows us to understand how the parameters of our model are connected to the terms in the decomposition. On the balanced growth path, the decomposition is

$$\frac{\Delta \log Z^{Entry}}{\Delta \log Z} = 1 - (1-\delta)\left(\frac{g_c}{g_e}\right)^{\gamma}, \tag{36}$$

$$-\frac{\Delta \log Z^{Exit}}{\Delta \log Z} = (1-\delta)\left(\frac{g_c}{g_e}\right)^{\gamma - \frac{1}{1-\alpha}} \frac{\log(g_e) - \log(g_c)}{\left(1-\alpha_k\right)\log(g_e)}, \tag{37}$$

$$\frac{\Delta \log Z^C}{\Delta \log Z} = (1-\delta)\left(\frac{g_c}{g_e}\right)^{\gamma-\frac{1}{1-\alpha}}\left[\left(\frac{g_c}{g_e}\right)^{\frac{1}{1-\alpha}} - \frac{\log(g_e)-\log(g_c)}{(1-\alpha_k)\log(g_e)}\right], \tag{38}$$

where $\Delta \log Z^{Entry}$ is the entry term in (4), $\Delta \log Z^{Exit}$ is the exit term in (4), and $\Delta \log Z^C$ is defined in (5). The contribution of net entry to aggregate productivity growth in the FHK decomposition is $(\Delta \log Z^{Entry} - \Delta \log Z^{Exit}) / \Delta \log Z$. To generate endogenous exit on the balanced growth path, we assume that $\overline{g} < g_e^{1-\varepsilon}$, which implies that $g_c < g_e$. Thus, the contribution of entry is bounded between $\delta$ and 1.

Before we discuss the relationship between model parameters and the importance of net entry in the FHK decomposition, note that, on the balanced growth path, the FHK decomposition of aggregate productivity growth, like the GDP growth rate, does not depend on the policy distortions $\varphi$, $\tau^{\kappa}$, and $\tau^{f}$. Any country on a balanced growth path, regardless of its levels of distortions, has the same FHK decomposition.

The analytic decompositions in (36)–(38) highlight the three fundamental forces that drive aggregate productivity growth in the model: firm turnover, related to $\delta$; firm heterogeneity and selection, governed by $\gamma$; and productivity growth in incumbent firms relative to entrants, determined by $g_e$ and $g_c$. We turn to comparative statics to demonstrate these relationships.

To understand the ways in which firm turnover shapes the decompositions, first consider the case in which $\delta$, the exogenous death probability, is one: All firms die at the end of each period. In this case, all aggregate productivity growth in the FHK decomposition is attributed to entrants. The contribution of the exit term is zero because it depends on the difference between the productivity of exiting firms and the overall productivity in the prior period when these firms were active, which, in this case, is zero, since the two sets of firms are identical.

As $\delta$ falls, more firms remain in operation from one period to the next and the fraction of productivity growth attributed to continuing firms in the FHK decomposition increases. The contribution of firm exit also increases. The larger mass of incumbent firms implies a larger mass of firms that endogenously exit. Finally, since a smaller $\delta$ implies less exit and thus less entry, the contribution from entry to aggregate productivity growth falls.

Firm heterogeneity on the balanced growth path is a function of the heterogeneity in the underlying distribution of entrant productivity, which is governed by $\gamma$. To see how firm

heterogeneity affects the FHK productivity decomposition, consider the limiting case in which $\gamma$ approaches infinity. Since $g_c < g_e$, the entry term accounts for all of the aggregate productivity growth in the FHK decomposition. When $\gamma$ approaches infinity, there is no heterogeneity within each cohort. The lack of heterogeneity in each cohort, along with the fact that entrants have higher productivities, implies that entrants will displace all of the continuing firms. In this case, even though the incumbent firms exit endogenously, they do not contribute to aggregate productivity growth because their productivity is the same as the average productivity in the previous period. If there is no selection, exit does not contribute to aggregate productivity growth in the FHK decomposition.

As $\gamma$ decreases, heterogeneity within each cohort increases. As a result, the entry term becomes less important in the FHK decomposition. Greater heterogeneity implies that there are high-productivity incumbent firms that do not exit. This also implies that the continuing term becomes more important, as more firms from previous cohorts remain. The importance of the exit term also increases, as the larger mass of continuing firms induces selection, forcing out firms that are relatively inefficient compared to continuing firms.

How does the difference in entrant and incumbent efficiency growth rates shape the productivity decomposition? Suppose $g_c = g_e$. This implies that the efficiency distributions of entering and continuing firms are the same. To see why, consider a cohort of firms that enters in period $t$. In period $t+1$, the efficiency distribution of the cohort has increased by a factor of $g_c$. Since $g_c = g_e$, the distribution of efficiencies of the cohort of entering firms is the same as that of the cohort that entered in the previous period. In this case, once a firm enters, it will only exit through exogenous death. The reason is that the firm cutoffs grow at $g_e$, which is the same growth factor as the efficiencies of continuing firms. Since the efficiency distributions are identical, the contribution of entering firms in the FHK decomposition is equal to their market share, which is given by the exogenous death probability of existing firms, $\delta$, and the contribution of continuing firms is characterized by their market share, $1-\delta$. Exiting firms do not contribute to productivity growth, since their productivity is the same as the average productivity in the previous period.

In the general case in which $g_c < g_e$, the entry term in the FHK decomposition always decreases with $g_c$. We can similarly show that the exit term is decreasing in $g_c$ whenever

$$\log\left(\frac{g_e}{g_c}\right) g_e < \frac{1-\alpha}{\gamma(1-\alpha)-1}. \tag{39}$$

In Section 7, we find that this condition is satisfied with the calibrated parameters. Thus, in the range of parameters we consider, the importance of entry and exit declines with $g_c$.

The balanced growth path analytics make it easy to see how firm turnover, selection, and the entrant productivity advantage shape the contribution of net entry to aggregate productivity growth. We cannot analytically characterize the decompositions off the balanced growth path, but the intuition we have developed here will carry over.

## 7. Quantitative Exercises

We now take our model to the data. We begin by calibrating the model so that it replicates key features of the U.S. economy. We think of the U.S. economy as being distortion-free, $\tau^f = \tau^\kappa = 0$ and $\varphi = 1$, so the calibration identifies the model's technological parameters. A period in the model is five years, the same length as the time window for the productivity decompositions.

After calibrating the model, we create three separate distorted economies with income levels that are 15 percent below that of the United States. The first distorted economy is the same as the United States except that entry costs are higher. Similarly, the second and third distorted economies are the same as the United States except for higher barriers to technology adoption and higher fixed continuation costs, respectively. We then introduce a reform into each of these distorted economies to determine whether the reforms can quantitatively match the relationships we observe in the data regarding GDP growth and the importance of entry and exit.

We find that the reforms to entry costs and barriers to technology adoption result in growth in GDP and aggregate productivity. Furthermore, we find that both of these reforms induce similar transition dynamics, including the importance of entry and exit in productivity growth in the FHK decomposition, during the reform. One important difference between the two reforms is that the mass of potential entrants increases more in the reform to entry costs. Even though the efficiency distribution of the potential entrants remains the same when entry costs are lowered, the increase in the mass of potential entrants increases the efficiency threshold. Thus, we find that lowering entry costs is almost equivalent to improving the efficiency distribution of potential entrants through the lowering of barriers to technology adoption.

Finally, we find that the reform to the fixed continuation cost causes an increase in GDP but results in a decline in aggregate productivity, which is not consistent with the data on Chile and Korea or with the evidence of other episodes from the literature. Furthermore, reforms that lead to a common increase in efficiency for all firms or reforms that benefit incumbents more than entrants are similarly not consistent with the growth episodes we study.

It is worth noting that $Y_t$ in the model is real GDP. Equation (21) shows that $Y_t$ is the sum of all consumption and investment in the economy. Furthermore, because the labor endowment is constant in the model, growth in $Y_t$ is the same as growth in real GDP per working-age person.

### 7.1. Calibration

We report the calibrated parameters in Table 4. We set the fixed continuation cost, $f^T$, so that the model generates an average establishment size of 14.0 employees, which is the mean during the period 1976 to 2000 as found in U.S. Census Bureau (2011). We set $\kappa^T$ so that the ratio of the entry cost to the annual fixed continuation cost, $\kappa^T / (f^T / 5)$, is 0.82, which is consistent with the findings of Barseghyan and DiCecio (2011), who survey the empirical literature on entry and continuation costs. We calibrate the tail parameter, $\gamma$, to match the standard deviation of establishment employment, which has an average value of 89.0 between 1976 and 2000 according to U.S. Census Bureau (2011). We set $g_e$ to be 1.02 so that on the balanced growth path, the model matches the long-term average growth rate of the U.S. economy, as discussed by Kehoe and Prescott (2002). The parameter $\alpha$ is chosen such that the labor share on the balanced growth path is 0.67. The discount factor, $\beta$, is set so that the model matches a real interest rate of 4 percent, which is consistent with McGrattan and Prescott (2005). The exogenous death rate, $\delta$, is set so that exiting plants destroy 19.3 percent of employment every five years, which is the average between 1976 and 2000 according to U.S. Census Bureau (2011).

Our empirical work studied the manufacturing sector, but our model is of the entire economy. To make the two comparable, we assume that net entry is as important for productivity growth in nonmanufacturing as it is in manufacturing. We are not aware of any work that calculates the FHK productivity decomposition for the entire U.S. economy. The paper by Garcia-Macia, Hsieh, and Klenow (2016), however, is one of the few papers that use data for the entire U.S. economy to study the relative importance of incumbents and entrants in accounting for productivity growth.

They find that incumbents account for the bulk of productivity growth in the economy. Although their results are consistent with the results of FHK for the manufacturing sector, we should be cautious in comparing the two results, since Garcia-Macia, Hsieh, and Klenow (2016) do not use the FHK decomposition but rather use a decomposition derived from their model. We set $\bar{g}$, which determines the efficiency growth rate of continuing firms $g_c$, to match the contribution of entry and exit to U.S. aggregate manufacturing productivity growth, which FHK find to be 25 percent.

**Table 4: Calibrated parameters**

| Parameter | | Value | Target |
|---|---|---|---|
| Operating cost (technological) | $f^T$ | 0.46×5 | Average U.S. establishment size: 14.0 |
| Entry cost (technological) | $\kappa^T$ | 0.38 | Entry cost/continuation cost: 0.82 |
| Tail parameter | $\gamma$ | 6.10 | S.D. of U.S. establishment size: 89.0 |
| Entrant efficiency growth | $g_e$ | $1.02^5$ | BGP growth rate of U.S.: 2 percent |
| Returns to scale | $\alpha$ | 0.67 | BGP labor share of U.S.: 0.67 |
| Death rate | $\delta$ | $1 - 0.96^5$ | Exiting plant employment share of U.S.: 19.3 percent |
| Discount factor | $\beta$ | $0.98^5$ | Real interest rate of U.S.: 4 percent |
| Firm growth | $g_c$ | $1.019^5$ | FHK contribution of entry and exit to U.S. manufacturing productivity growth: 25 percent |
| Spillover term | $\varepsilon$ | 0.64 | Authors' estimate |

We next pin down $\varepsilon$, which characterizes the relationship between continuing-plant and aggregate efficiency growth. In the data, we observe an increase in the productivity growth of continuing plants when there is an increase in industry-level productivity growth. Ideally, for this exercise we would like to use data for all U.S. plants, but without access to these data, we use data for Chilean and Korean manufacturing plants. To quantify this relationship, we take the logarithm of (12)

$$\log g_{ct} = \log \bar{g} + \varepsilon \log g_t \,, \tag{40}$$

to arrive at an equation that we can estimate using plant-level data. Using ordinary least squares, we estimate,

$$\log g_{ct,i} = \beta_0 + \varepsilon \log g_{it} + \upsilon_{it} \,, \tag{41}$$

where $g_{ct,i}$ is the productivity growth of continuing plants of industry $i$ (weighted by the gross output of plants), $g_{it}$ is the aggregate productivity growth in industry $i$, and $\upsilon_{it}$ is an error term. In the data, a continuing plant is one that is present at both the beginning and the end of the sample window. Although $\varepsilon$ governs the growth rate of continuing-firm efficiency, we use productivity data to estimate (41). The estimated $\varepsilon$ is nonetheless model consistent, since log productivity is a linear transformation of log efficiency. The constant term in the regression is not an estimate of $\overline{g}$.

**Table 5: Productivity spillover estimates**

| | Chile | | Korea | | |
|---|---|---|---|---|---|
| | 1995–1998 | 2001–2006 | 1992–1997 | 2002–2007 | 2009–2014 |
| Industry productivity growth | 0.720*** | 0.834*** | 0.551*** | 0.700*** | 0.378*** |
| | (0.051) | (0.054) | (0.079) | (0.036) | (0.043) |
| Observations | 92 | 89 | 138 | 170 | 179 |
| Adj. *R*-squared | 0.69 | 0.73 | 0.26 | 0.69 | 0.30 |

Notes: Estimates of (41) using plant-level data from Chile and Korea. Standard errors are reported in parentheses. *** Denotes $p < 0.01$.

Table 5 reports the results of the regression across the five windows we study. We find that the regression coefficient ranges from 0.38 to 0.70 for Korea and from 0.72 to 0.83 for Chile. We use the average over the five estimates to find that $\varepsilon = 0.64$.

One concern in this estimation is that we are not measuring spillovers but rather an unrelated factor that affects the correlation between plant productivity growth and industry productivity growth (for example, Manski, 1993). A second concern is that although we are calibrating the model to an economy that is on the balanced growth path, we estimate $\varepsilon$ using plant-level data for countries that are not on a balanced growth path. The second concern, however, is mitigated by the lack of a systematic relationship between the regression coefficient and whether the economy is in a period of fast growth.

We study the robustness of our results by redoing the quantitative exercise when $\varepsilon = 0.38$ and $\varepsilon = 0.83$, which are the range of estimates for $\varepsilon$ in Table 5. These results are reported in Appendix K. For both cases, the model matches the positive correlation between fast growth and the contribution of net entry. If it is the case that our estimate of $\varepsilon$ is biased upward (for example, there is an unobserved factor that positively affects both the productivity growth of continuing

plants and the entire industry during periods of fast growth), then it is useful to focus on the robustness exercise that uses lower values of $\varepsilon$. The results show that lower values of $\varepsilon$ result in a greater contribution of net entry because of the diminished spillovers to continuing firms.

We now compare the efficiency growth rates of continuing and entering firms in the calibrated economy. As mentioned before, the efficiency distribution of entrants has a growth factor of $g_e = 1.02^5$. We use (12) to compute the efficiency growth factor of continuing firms and arrive at $g_c = 1.019^5$, using the fact that average efficiency grows by $g_e$ on the balanced growth path. Note that condition (39), which is the condition under which increases in $g_c$ lead to a decline in the importance of entry and exit in the FHK decomposition, is satisfied under the calibrated parameters.

### 7.2. Policy Reforms in Chile and Korea

In Appendix L, we summarize the key reforms conducted in Chile and Korea during the periods of fast growth. For Chile, we consider reforms in the 1993−1997 period, affecting the 1995−1998 window. For Korea, we consider reforms in the 1990−1995 period and the 1998−2004 period, affecting the 1992−1997 window and the 2002−2007 window, respectively.

We attempt to map these reforms to changes in the policy variables in our model, which are entry and fixed continuation costs and barriers to technology adoption. We find that the types of reforms that Chile and Korea undertook are mostly consistent with the lowering of entry costs and barriers to technology adoption. For example, we find that both Chile and Korea relaxed restrictions on foreign direct investment (FDI), which reduces the barriers to technology adoption, since it improves access to foreign technologies. Similarly, both of these countries made reforms to their financial systems, making it easier for firms to finance large up-front costs and, in that sense, lower barriers to technology adoption and entry costs. Midrigan and Xu (2014) use a model of establishment dynamics with financial frictions calibrated to Korean manufacturing plants and find that financial frictions primarily distort entry and technology adoption decisions. Finally, the Korean government instituted pro-competitive reforms to allow for greater competition, which lowers entry costs.

We do not find that either Chile or Korea implemented major trade reforms during the periods of fast growth. It is worth noting, however, that the literature on trade and productivity emphasizes improvements in the efficiency distribution of firms resulting from a trade reform. In that sense,

reforms to barriers to technology adoption in the model have features that resemble the efficiency gains emphasized by this literature. For instance, Sampson (2016) builds a model in which potential entrants draw efficiencies from a distribution that is related to the efficiency of incumbent firms. In this model, trade reforms lead to the exit of unproductive firms, which results in the improvement of the efficiency distribution from which entrants draw. Perla, Tonetti, and Waugh (2015) and Buera and Oberfield (2016) also build models in which trade reforms lead to an improvement in the efficiency distribution from which firms draw.

### 7.3. Policy Reforms in the Model

In this section, we consider policy reforms that move the economy to a higher balanced growth path by lowering either entry costs, barriers to technology adoption, or the fixed continuation costs. The goal of these experiments is to determine whether these types of reforms can quantitatively account for the contribution of entry and exit to productivity growth in the FHK decomposition during periods of fast GDP growth. Although the reforms that Chile and Korea implemented over this period are most similar to reducing entry costs and barriers to technology adoption, we examine the quantitative results of reductions in the fixed continuation costs. We also simulate a common efficiency increase for both entrants and incumbents in order to study whether policies that lead to a common efficiency increase can account for the patterns we document.

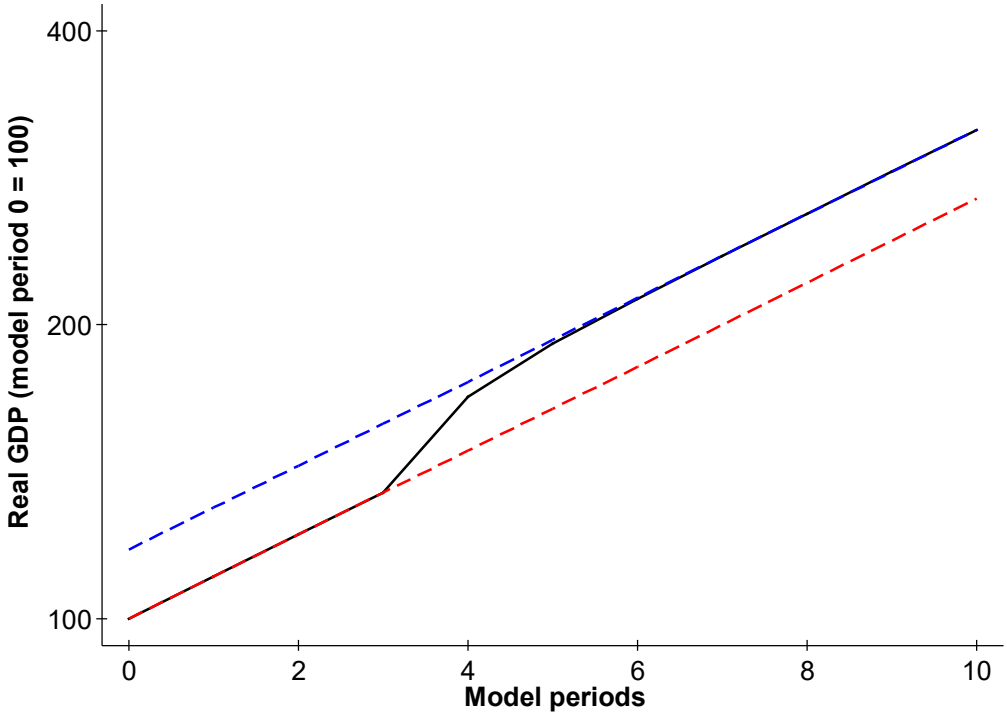
We first create three separate distorted economies. Each economy is parameterized as the U.S. economy, with one exception. In the first distorted economy, we increase the policy-related portion of the entry costs, $\tau^{\kappa}$, so that GDP on the balanced growth path is 15 percent lower than in the nondistorted economy. In the second and third distorted economies, we raise the barriers to technology adoption, $\varphi$, and the policy-related portion of the fixed continuation cost, $\tau^{f}$, so that GDP on the balanced growth path also declines 15 percent, respectively, in each of these economies. This requires setting $\kappa = 0.74$ and $\varphi = 1.12$ and $f = 4.48$.

#### 7.3.1 Reform: Entry Costs

We institute a reform by eliminating the distortion in each economy and then studying the transition to the new balanced growth path. We begin by reporting the results of the reform that reduces entry costs. In Figure 4, we plot GDP. The transition of the economy is quick, and within two model periods, the economy is very close to converging to the new balanced growth path.

GDP grows 4.6 percent annually in the initial 5-year period after the reform and quickly falls to 2 percent.

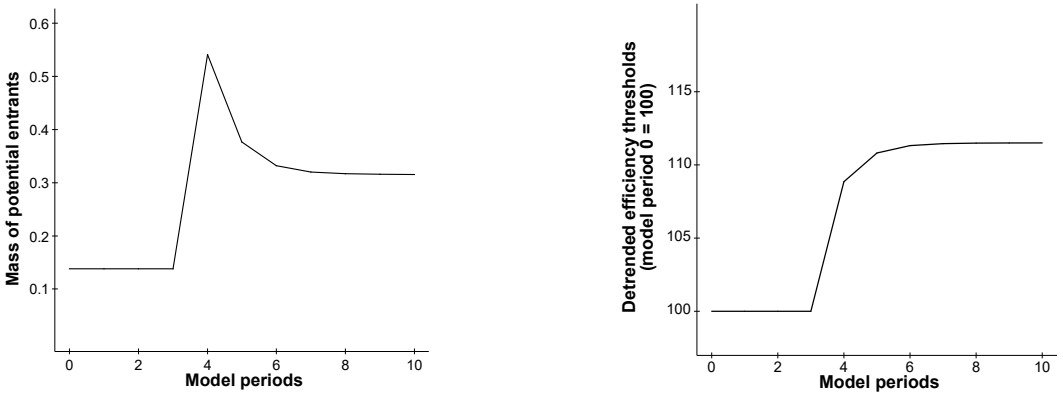
**Figure 4: Real GDP (entry cost reform)**




To understand the mechanisms at work in the model, we plot key economic variables during the transition. The smaller entry costs lead to a permanent increase in the mass of potential entrants, as seen in Figure 5(a). The increase in the mass of potential entrants leads to an increase in the efficiency threshold needed for an entrant to successfully operate. There is also an increase in the mass of failed entrants. In Figure 5(b), we plot the efficiency threshold, normalizing the first period value to 100. The series has been detrended by dividing the threshold by $g_e^t$ so that the detrended efficiency threshold is constant when the economy is on the balanced growth path. Note that we have exit in each cohort, so the threshold efficiency level is the same for all incumbents and successful entrants.

**Figure 5: Potential entrants and efficiency thresholds (entry cost reform)**

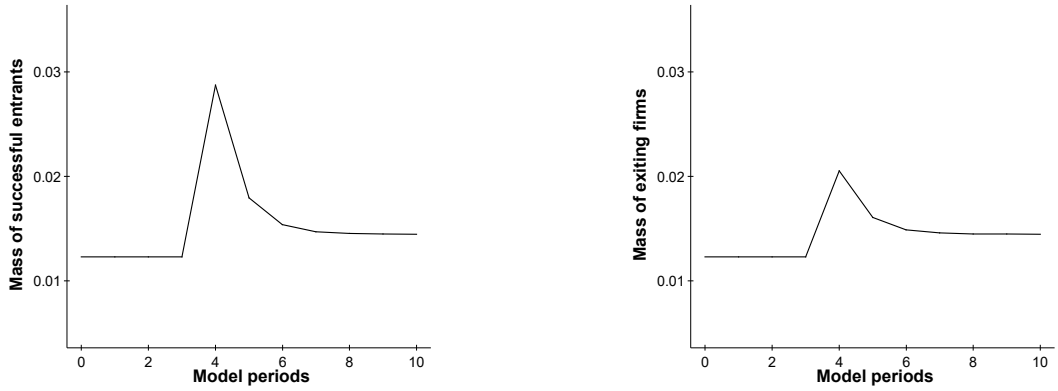
**(a) Mass of potential entrants** **(b) Detrended efficiency thresholds**




In Figure 6, we plot firm entry and exit. The reform leads to a spike in firm turnover during the transition, and firm turnover is permanently higher on the new balanced growth path. We also see that during the transition, relatively inefficient firms exit and relatively efficient firms enter, which drives the increased importance of entry and exit for productivity growth during periods of fast growth in GDP.

**Figure 6: Firm entry and exit (entry cost reform)**

**(a) Mass of successful entrants** **(b) Mass of exiting firms**




Other model variables exhibit patterns similar to the neoclassical growth model. We plot consumption and interest rates in Figure 7. To understand their behavior, recall that creating new firms is investment: The household forgoes consumption to create long-lived firms that increase future income. Decreasing entry costs leads to an increase in the demand for potential entrants. As

a result, there is an increase in the interest rate during the reform and a decline in consumption growth. As the investment boom subsides, consumption rises to its new balanced growth path value.

**Figure 7: Consumption and interest rates (entry cost reform)**

**(a) Detrended consumption** **(b) Interest rate**

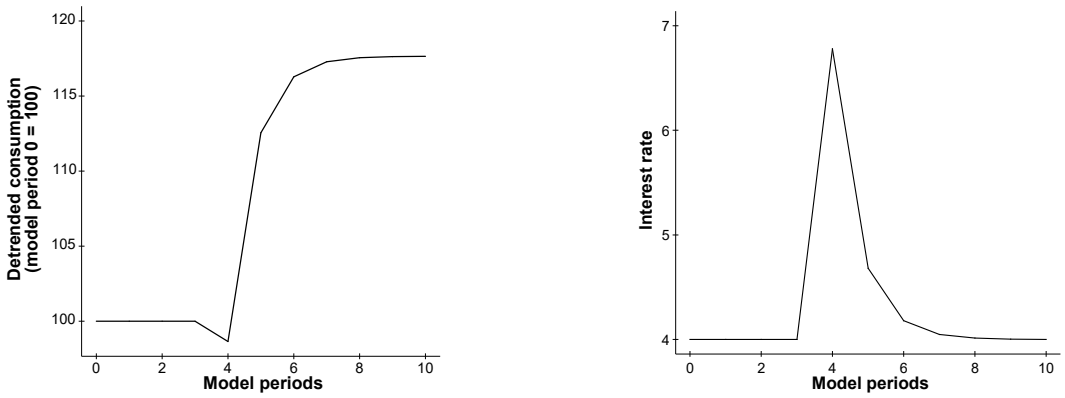



Table 6 reports the GDP and productivity growth rates and the contribution of net entry to productivity growth in the FHK decomposition when we decrease entry costs in the model. Before the reform, the calibrated economy is on a balanced growth path in which GDP grows at 2 percent per year and net entry contributes 25 percent of aggregate productivity growth. During the reform period, GDP grows at an annualized rate of 4.6 percent and there is a surge in the contribution of net entry to 59.6 percent. Note that increases in the aggregate capital stock imply that productivity growth is smaller than GDP growth.

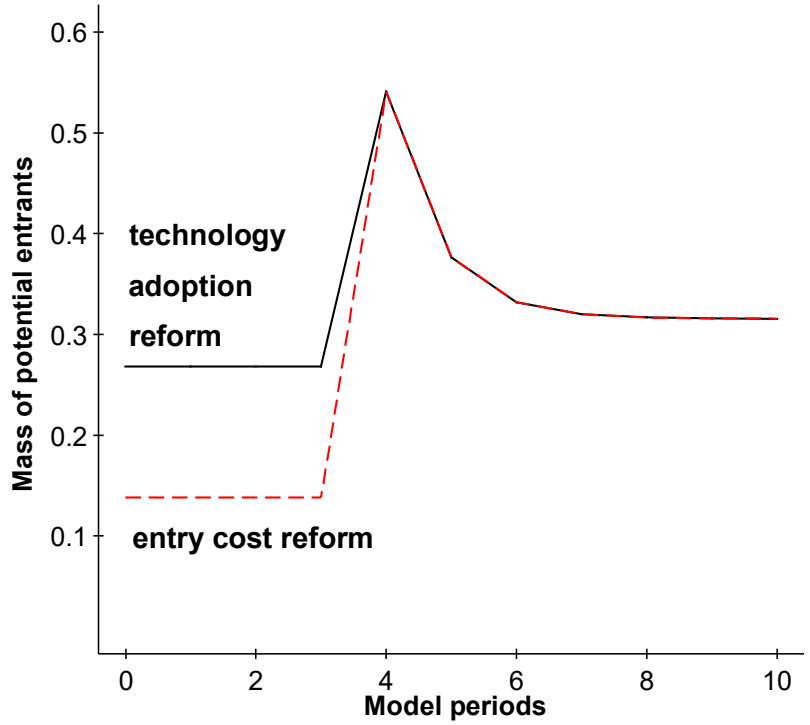
**Table 6: Productivity decompositions (entry cost reform)**

| Model periods (five years) | Entry cost | Real GDP growth (percent, annualized) | Aggregate productivity growth (percent, annualized) | Contribution of net entry to aggregate productivity (percent) |
|---|---|---|---|---|
| 0–3 | 0.74 | 2.0 | 1.3 | 25.0 |
| 4 (reform) | 0.38 | 4.6 | 2.9 | 59.6 |
| 5 | 0.38 | 2.5 | 1.5 | 36.5 |
| 6 | 0.38 | 2.1 | 1.3 | 28.1 |
| 7+ | 0.38 | 2.0 | 1.3 | 25.0 |

### 7.3.2 Reform: Barriers to Technology Adoption

Our second reform, lowering the barriers to technology adoption $(\varphi)$, generates outcomes similar to those from lowering entry costs. For example, when a reform to $\varphi$ takes place (period 4), GDP growth and the FHK contribution of net entry are the same up to the first decimal place as those reported in Table 6, while aggregate productivity growth is a little lower (2.7 percent). The figures that characterize the key economic variables for the reform to barriers to technology adoption are similar to those in Figures 4–7.

**Figure 8: Mass of potential entrants (entry cost vs. barriers to technology adoption reform)**




The only substantial difference between the two reforms is that the mass of potential entrants increases less after the reform to $\varphi$. In Figure 8, we plot the mass of potential entrants under both reforms. Note that after the reform, both economies converge to the same nondistorted economy, so the reform to entry costs generates a larger increase in potential entrants. The change in entry costs generates more potential entry because, as seen in (26), lowering $\kappa$ directly affects the mass

of potential entrants. This is in addition to the indirect effects that operate through $\lambda$. Lowering $\varphi$, however, does not have a direct effect on the mass of potential entrants, only an indirect effect.

### 7.3.3 Reform: Fixed Continuation Cost

We now evaluate the effect of reforms to the fixed continuation cost. Two opposing forces influence how the reform will affect the efficiency of the firms in the economy. On the one hand, lower continuation costs make it more attractive to operate a firm and thus the mass of potential entrants increases. An increase in the mass of potential entrants would raise the efficiency threshold. On the other hand, lower continuation costs may allow for less efficient firms to operate, which would lower the efficiency threshold.

We report the results of this reform in Table 7. A surge in GDP growth occurs immediately after the reform. This reform leads to a decline in aggregate productivity, indicating that the second effect mentioned above dominates. Note the contrast between lowering entry costs and lowering fixed continuation costs. In equilibrium, the former generates more potential entrants, thereby raising the efficiency threshold needed to operate. The latter discourages unproductive firms from exiting once they are operating. In the data, we observe that periods of higher GDP growth are associated with higher productivity growth, which is not consistent with reforms to the fixed continuation cost in the model. Given this counterfactual implication, we do not further study reforms to the fixed continuation cost.

**Table 7: Productivity decompositions (fixed continuation cost reform)**

| Model periods (five years) | Operation cost | Real GDP growth (percent, annualized) | Aggregate productivity growth (percent, annualized) | Contribution of net entry (percent) |
|---|---|---|---|---|
| 0–3 | 4.48 | 2.0 | 1.3 | 25.0 |
| 4 (reform) | 2.32 | 4.1 | −1.1 | 88.8 |
| 5 | 2.32 | 2.8 | 1.1 | 36.9 |
| 6 | 2.32 | 2.2 | 1.2 | 28.5 |
| 7+ | 2.32 | 2.0 | 1.3 | 25.1 |

### 7.3.4 Common Efficiency Shock

In Appendix J, we simulate a common increase in efficiency for all firms, including incumbents and entrants. We find that this common increase in efficiency, which benefits both incumbents and

entrants in a similar manner, does not lead to an increase in the contribution of entry and exit. Furthermore, we even find that there is a decline in the importance of entry and exit during the transition. The reason is that while the continuing and entry terms in the FHK decomposition increase by the same amount proportionally, the exit term does not change. The exit term remains unchanged because neither the market share of exiters nor their relative productivities change. As a result, the share of productivity growth accounted for by entry and exit declines.

Based on this finding, we can also rule out other reforms that improve the efficiency of incumbents relative to that of entrants. The reason is that it would lead to an even larger decrease in the contribution of entry and exit.

### 7.4. Robustness to Alternative Modeling Choices

Our findings are robust to alternative modeling choices. In Appendix F–Appendix I we present alternative models and perform similar exercises as we do with the baseline model. For each model, we characterize the balanced growth path and we recalibrate the model and perform the same quantitative experiments as before (that is, we create distorted economies with higher entry costs and barriers to technology adoption). We find that the transition dynamics are similar to those of the baseline case in that the contribution of net entry increases immediately after the reform. We conclude that our results are robust to different modeling choices.

In Appendix F, we consider a model in which the fixed costs are denominated in labor rather than the consumption good, which is another common approach in the literature. In Appendix G, we re-calibrate the model in Appendix F in which labor in the model is interpreted as being a composite input of labor and capital. This formulation allows for firms to have different levels of variable capital. Appendix H presents a model with monopolistically competitive firms that produce differentiated products. In Appendix I, we allow for continuing firms to be subject to idiosyncratic efficiency growth shocks. The model with idiosyncratic growth shocks and the baseline model yield similar results when the average growth rate of continuing firms is calibrated to match the same contribution of entry and exit.

### 7.5. Net Entry in the Model and the Data

In this section, we examine the extent to which reforms to entry costs and barriers to technology adoption quantitatively match the contribution of net entry to aggregate productivity growth in the

FHK decomposition that we observe in the data during periods of fast growth. In Table 8, we report growth in GDP per working-age person and the contribution of net entry to aggregate manufacturing productivity growth in the data. Since Table 3 has multiple observations for countries that are experiencing fast and slow growth, we report the average GDP per working-age person growth and the contribution of net entry to productivity growth over all the fast-growing economies and all the slow-growing economies. We also report the equivalent statistics from the model. Recall that the labor endowment is fixed in the model, which implies that growth in GDP is equivalent to growth in GDP per working-age person.

**Table 8: Contribution of net entry: Model and data**

| | Real GDP per working-age person growth (percent, annualized) | Contribution of net entry to productivity growth (percent) |
|---|---|---|
| Data fast growth | 5.8 | 47 |
| Model reform ($\kappa$) | 4.6 | 60 |
| Model reform ($\varphi$) | 4.6 | 60 |
| Data slow growth | 2.1 | 22 |
| Model BGP | 2.0 | 25 |

During periods of slow growth in GDP, which correspond to the balanced growth path in our model, the model is calibrated to generate the GDP growth rate and the FHK contribution of net entry that we observe in the U.S. data. We have not used any of the model's transition path behavior in the calibration, so the net entry contribution following reform is informative about the model's performance. The model successfully matches the patterns we find in the data. GDP in the model grows at 4.6 percent during the reform, compared to 5.8 percent in the data. The contribution of net entry during this period is 60 percent in the model, compared to 47 percent in the data.

We further analyze the model's outcomes by studying the relative productivity of entrants or exiters and their gross output shares. In Table 9, we report the results from our model as well as a summary of the data found in Table 2. Overall, the model matches these nontargeted moments well. During periods of fast growth, entrants in the model are 14 percent more productive than the average firm in the previous period, compared to 17 percent in the data. During periods of slower GDP growth, the relative productivity of entrants falls to 6 percent in the model, compared to 2 percent in the data. Similarly, during periods of fast growth, exiters are 10 percent less productive

than the average firm in the model, compared to 12 percent less productive in the data. During periods of slow growth, the model also generates exiters that are 2 percent less productive than the average firm, compared to 5 percent in the data.

**Table 9: Relative productivity and market share of entrants and exiters: Model and data**

| Period | Aggregate productivity growth (percent) | Relative productivity of entrants (percent) | Entrant market share | Relative productivity of exiters (percent) | Exiter market share |
|---|---|---|---|---|---|
| Fast growth | | | | | |
| Data | 18.3 | 16.8 | 0.30 | −11.7 | 0.26 |
| Model reform ($\kappa$) | 14.1 | 14.1 | 0.42 | −9.5 | 0.27 |
| Model reform ($\varphi$) | 14.0 | 14.0 | 0.42 | −9.5 | 0.27 |
| Slow growth | | | | | |
| Data | 8.8 | 2.2 | 0.32 | −4.8 | 0.24 |
| Model BGP | 6.4 | 6.4 | 0.20 | −1.6 | 0.19 |

Notes: The relative productivity term is the average entrant (or exiter) firm productivity at $t$ (or $t-1$) relative to the average productivity of all firms in $t-1$.

Table 9 also indicates that the model does not completely match all features of the data. In particular, changes in shares play an important role in the model but not in the data. In the model, the entrants' market share increases from 20 percent in periods of slow growth to 42 percent in periods of fast growth, whereas there is no such corresponding increase in the data. Similarly, the exiter market share in the model increases from 19 percent in periods of slow growth to 27 percent in periods of fast growth, qualitatively matching the increase in exiter market share in the data. Our simple model of firm dynamics captures the relative productivity of entering and exiting firms reasonably well. This is important because Table 2 indicates that changes in the contribution of entry and exit in the FHK decomposition are mainly driven by changes in the relative productivity of entrants and exiters. A more nuanced model of firm growth may be able to better capture the behavior of market shares, but our model performs well along many dimensions and is simple enough to retain analytic tractability.

## 8. Conclusion and Direction for Future Research

Our work suggests three areas for future research. First, this paper, as well as most of the literature that studies aggregate productivity growth, has focused on the manufacturing sector. Because of

this limitation, we have assumed that the fraction of productivity growth accounted for by entry and exit in the FHK decomposition is the same in manufacturing as it is in the entire economy. Decomposing productivity for an entire economy, especially an economy that has experienced both fast and slow growth, would be useful to better understand the importance of entry and exit during periods of fast and slow growth. We are not aware of any study that has calculated the FHK decomposition for the entire economy using firm- or plant-level TFP as the measure of productivity.

A second area of future research is to extend our model to an open economy setting. In a model with international trade, a trade reform generates incentives to attempt entry and will affect the importance of entry and exit in the FHK decomposition. If the economy is open to international capital flows, then it would not see an increase in the interest rate after a reform. In our economy, the rising interest rate slows down the transition. An economy that is open to capital flows will see a faster transition.

A final area of research is to understand how being a potential entrant (an entrepreneur who has taken an efficiency draw), a failed entrant (a potential entrant who does not have an efficiency high enough to operate), and a successful entrant (a potential entrant who has an efficiency high enough to operate) maps to the data. For example, a longitudinal study of business creation, the Panel Study of Entrepreneurial Dynamics, documents the different stages of creating a new business (Reynolds and Curtin, 2011). After 72 months, 30 percent have begun production, 48 percent have quit, and 22 percent are still in the start-up process. Do we consider a potential entrant to be a start-up, a failed entrant to be a start-up that quit, and a successful entrant to be a start-up that began production? An alternative interpretation is given by Bartelsman, Haltiwanger, and Scarpetta (2013), who, in their calibration, interpret failed entrants as businesses that do not survive the first five years.

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## Appendix A: Data Appendix

### A.1. Data Description for Chilean Manufacturing Productivity Decompositions

We use the ENIA (*Encuesta Nacional Industrial Anual*) data set provided by the Chilean statistical institute INE (*Instituto Nacional de Estadística*) in September 2014. Similar data are now publicly available through the INE website. The data set is a panel of all manufacturing establishments in Chile with more than 10 employees covering 1995–2006. The data use the 4-digit ISIC Rev. 3 industry classification system. To give a sense of the level of disaggregation, we note that ISIC Rev. 3 has 127 industries.

The first step is to compute plant-level productivity. We assume that plant $e$ in industry $t$ operates the following production function:

$$\log y_{eit} = \log z_{eit} + \beta_k^i \log k_{eit} + \beta_\ell^i \log \ell_{eit} + \beta_m^i \log m_{eit}, \tag{A1}$$

where $z_{eit}$ is the plant's productivity, $y_{eit}$ is gross output, $k_{eit}$ is capital, $\ell_{eit}$ is total labor measured in man-years, $m_{eit}$ is intermediate inputs, and $\beta_j^i$ is the coefficient of input $j$ in industry $i$.

We construct gross output and factor inputs in the same manner as Liu and Tybout (1996) and Tybout (1996). Gross output is the sum of total income (sales of goods produced; goods shipped to other establishments; resales of products; and work, repairs, and installations for third parties), electricity sold, buildings produced for own use, machinery produced for own use, vehicles produced for own use, goods produced that go to inventory (final inventory of goods in process plus final inventory of goods produced minus initial inventory of goods in process minus initial inventory of goods produced). For intermediate inputs, we include the purchases of intermediates (materials, fuels, goods purchased for resale, cost of work done by third parties, water, greases, and oil), electricity, and the materials used from inventories (initial inventories minus final inventories). We use gross output and intermediate input deflators at the 4-digit level (ISIC Rev. 3) to convert these variables into 1995 pesos. These deflators were created by the INE to be used with the ENIA plant-level data. For the labor input, we use man-years, adjusted for labor quality (between blue-collar and white-collar workers) using relative wages.

In constructing the real capital stock, we consider three types of capital: buildings, machinery, and vehicles. We use the book value of capital reported by firms and use an investment deflator to arrive at the real stock of capital in 1995 pesos.

To find the parameters $\beta_k^i$, $\beta_\ell^i$, and $\beta_m^i$ of the production function, we use nominal industry cost shares for each input. The cost shares we calculate are at the 4-digit industry level for each input, averaged over the beginning and end of the period. For cost of labor, we use total employee remuneration. For intermediate input usage, we use the nominal value constructed to create the real intermediate input usage.

We do not have a direct measure of the user cost of capital to use in computing the cost share of capital. We use the no-arbitrage relationship to find the user cost of capital, $j$,

$$R_{jt} = \max\left\{1 + r_t - (1-\delta_j)\frac{P_t}{P_{t+1}}\frac{P^K_{t+1,j}}{P^K_{tj}}, \delta_j\right\}, \tag{A2}$$

where $R_{jt}$ is the user cost of capital, $P_t$ is the price level of the aggregate economy, $P^K_{tj}$ is the price of a unit of capital type $j$ in period $t$, and $r_t$ is the real interest rate. For $r_t$ we use the economy-wide real interest rate, for $P_{t+1}/P_t$ we use the GDP deflator, and for $P^K_{t+1,j}/P^K_{tj}$ we use the aggregate investment deflator.

Given real input factors and cost shares, we determine the productivity of plant $e$ in industry $i$ as

$$\log z_{eit} = \log y_{eit} - \left(\beta_k{}^i \log k_{eit} + \beta_\ell{}^i \log \ell_{eit} + \beta_m{}^i \log m_{eit}\right). \tag{A3}$$

We can thus calculate the industry-level productivity $Z_{it}$ for industry $i$ for all years using (1). Furthermore, we decompose these changes in industry-level productivity using (2), (3), (4), and (5). To compute the changes in aggregate productivity, we weight the productivity growth of each industry by the fraction of nominal gross output accounted for by that industry, averaged over beginning and end. We follow the exact same process to compute the aggregate contribution of continuing firms and net entry.

## A.2. Data Description for Korean Manufacturing Productivity Decompositions

We use the Mining and Manufacturing Survey from the Korean National Statistical Office. The Microdata Service Division of Statistics Korea provides microdata through the Microdata Integrated Service (MDIS) system (https://mdis.kostat.go.kr/index.do) for a fee to approved users. This data set is a panel that covers all manufacturing establishments in Korea with at least 10 workers. We have three panels: 1992–1997, 2001–2006, and 2009–2014. Each plant's industry is given at the 5-digit level using the Korean Standard Industrial Classification (KSIC Rev. 6 for 1992–1997, Rev. 8 for 2001–2006, and Rev. 9 for 2009–2014).[7] As in the Chilean data, we use 4-digit KSIC industries as the main unit of industry analysis.

The first step is to compute plant-level productivity. We assume that plant $e$ in industry $i$ operates the following production function:

$$\log y_{eit} = \log z_{eit} + \beta_k^i \log k_{eit} + \beta_\ell^i \log \ell_{eit} + \beta_m^i \log m_{eit}, \tag{A4}$$

where $y_{eit}$ is gross output, $z_{eit}$ is total factor productivity, $k_{eit}$ is capital, $\ell_{eit}$ is labor, $m_{eit}$ is intermediate inputs, and $\beta_j^i$ is the coefficient of input $j$ in industry $i$.

For gross output, we use the production value reported in Korean won. We use producer price indices (obtained from the Bank of Korea, henceforth BOK), broken down at the 4-digit level, to put this series into real 2010 Korean won. For labor, we use the number of production workers plus a quality-adjusted estimate of nonproduction workers. As in Baily, Hulten, and Campbell (1992), the adjustment is made using the relative earnings of nonproduction workers, calculated separately for each plant.[8] For the capital stock, we consider three types of capital: buildings and structures, machinery and equipment, and vehicles and ships. We use the average reported book value of each type of capital at the beginning and end of each year, deflated by the GDP deflator for gross fixed capital formation (BOK). Once we have computed the real capital stock series, we sum the value of buildings and structures, machinery and equipment, and vehicles and ships to obtain the total capital stock of the plant,

$$k_{et} = \sum_j k_{eitj}. \tag{A5}$$

[7] KSIC Revs. 6 and 8 are comparable to the International Standard Industrial Classification (ISIC Rev. 3), and KSIC Rev. 9 is comparable to ISIC Rev. 4.

[8] For the 2009–2014 window, in which employees are reported as full-time and temporary workers, the analogous adjustment is made for temporary workers.

For intermediate inputs, we use the total value of materials, electricity, fuel, and water usage, and outsourced processing costs reported by the plant in Korean won. We use intermediate input deflators constructed using the input-output matrix (BOK) to convert this series into real 2010 Korean won. We build three sets of deflators: one based on KSIC Rev. 6 using the input-output matrix for 1995, one based on KSIC Rev. 8 using the input-output matrix for 2003, and one based on KSIC Rev. 9 using the input-output matrix for 2011. We obtain the matrix of intermediate deflators, $D$, by

$$\underbrace{D}_{\text{industry codes}\times\text{years}} = \exp\left[\underbrace{I}_{\text{industry codes}\times\text{product codes}} \cdot \log\left(\underbrace{P}_{\text{product codes}\times\text{years}}\right)\right], \tag{A6}$$

where $I$ is the input-output matrix and $P$ is the matrix of the producer price indices by year.

The factor elasticities $\beta_k$, $\beta_\ell$, and $\beta_m$ of the production function are obtained using the 4-digit industry average nominal cost shares, averaged over the beginning and ending year of the sample period. For the labor input, we use the total annual salary reported by the plant in Korean won. For capital, we impute the user cost of capital $j$, $R_{jt}$, as

$$R_{jt} = \max\left\{1 + r_t - (1-\delta_j)\frac{P_t}{P_{t+1}}\frac{P^K_{t+1,j}}{P^K_{tj}}, \delta_j\right\}, \tag{A7}$$

where $r_t$ is the real interest rate, $\delta_j$ is the depreciation rate for capital of type $j$, $P_t$ is the price level of the aggregate economy, and $P^K_{tj}$ is the price of a unit of capital type $j$ in period $t$. For $r_t$ we use the economy-wide real interest rate, for $P_{t+1}/P_t$ we use the GDP deflator, and for $P^K_{t+1,j}/P^K_{tj}$ we use the aggregate investment deflator. Following Levinsohn and Petrin (2003), we use depreciation rates of 5 percent for buildings and structures, 10 percent for machinery and equipment, and 20 percent for vehicles and ships.

Given these estimates, the productivity of plant $e$ in industry $i$ at time $t$ is

$$\log z_{eit} = \log y_{eit} - \left(\beta^i_k \log k_{eit} + \beta^i_\ell \log \ell_{eit} + \beta^i_m \log m_{eit}\right). \tag{A8}$$

## Appendix B: Sensitivity of Empirical Results

### B.1. Alternative Decompositions for Chile and Korea

To check the robustness of our findings for Chile and Korea, we consider alternative decompositions proposed by Griliches and Regev (1995) and Melitz and Polanec (2015), henceforth GR and MP, respectively. In particular, we decompose aggregate manufacturing productivity growth over the same windows using the GR and MP decompositions to see if the contribution of net entry is higher during the period of fast growth. Furthermore, we decompose productivity growth using model output to examine the contribution of net entry on the balanced growth path and during the transition.

It is informative to see that the net entry term, $\Delta \log Z_{it}^{NE}$, and the continuing term, $\Delta \log Z_{it}^{C}$, can be rewritten using aggregate statistics of entering, exiting, and continuing plants as described by Melitz and Polanec (2015). To do so, we first rewrite the end-of-window productivity of industry $i$ at time $t$ as

$$\log Z_{it} = s_{it}^{N} \log Z_{it}^{N} + s_{it}^{C} \log Z_{it}^{C}, \tag{A9}$$

where $s_{it}^{N}$ is the share of gross output accounted for by entering plants in industry $i$ at time $t$, and $Z_{it}^{N}$ is the aggregate productivity of entering plants at time $t$, and likewise for continuing plants $(C)$. In the same manner, we rewrite the beginning-of-window industry productivity at time $t-1$ as

$$\log Z_{i,t-1} = s_{i,t-1}^{C} \log Z_{i,t-1}^{C} + s_{i,t-1}^{X} \log Z_{i,t-1}^{X}, \tag{A10}$$

where $s_{i,t-1}^{X}$ is the share of gross output accounted for by exiting plants at time $t-1$. Notice that an entering plant is only active at time $t$, and an exiting plant is only active at time $t-1$.

Second, we rewrite (4) and (5) of the FHK decomposition as

$$\Delta \log Z_{it}^{NE} = \underbrace{s_{it}^{N}\left(\log Z_{it}^{N} - \log Z_{i,t-1}\right)}_{\text{entry term}} - \underbrace{s_{i,t-1}^{X}\left(\log Z_{i,t-1}^{X} - \log Z_{i,t-1}\right)}_{\text{exit term}} \tag{A11}$$

and

$$\Delta \log Z_{it}^{C} = \underbrace{s_{i,t-1}^{C}\left(\log Z_{it}^{C} - \log Z_{i,t-1}^{C}\right)}_{\text{within term}} + \underbrace{\left(s_{it}^{C} - s_{i,t-1}^{C}\right)\left(\log Z_{it}^{C} - \log Z_{i,t-1}\right)}_{\text{reallocation term}}. \tag{A12}$$

Note that the entry, exit, within, and reallocation terms in (A11) and (A12) are the same as those in (4) and (5). Thus, the only statistics needed to calculate the FHK decompositions are the weighted productivity of continuing, entering, and exiting plants as well as their share of output.

The MP decomposition rewrites the continuing and net entry terms as

$$\begin{aligned}\Delta \log Z_{it}^{C} &= \log Z_{it}^{C} - \log Z_{i,t-1}^{C} \\ \Delta \log Z_{it}^{NE} &= s_{it}^{N}\left(\log Z_{it}^{N} - \log Z_{it}^{C}\right) - s_{i,t-1}^{X}\left(\log Z_{i,t-1}^{X} - \log Z_{i,t-1}^{C}\right).\end{aligned} \tag{A13}$$

Notice that the reference group for new plants is the productivity of continuing plants at time $t$, and the reference group for exiting plants is the productivity of continuing plants at time $t-1$. The change in reference group would affect the net entry term.

Lastly, we can write the GR decomposition as

$$\begin{aligned}\Delta \log Z_{it}^{C} &= s_{it}^{C}\left(\log Z_{it}^{C} - \log \overline{Z_{it}}\right) - s_{i,t-1}^{C}\left(\log Z_{i,t-1}^{C} - \log \overline{Z_{it}}\right) \\ \Delta \log Z_{it}^{NE} &= s_{it}^{N}\left(\log Z_{it}^{N} - \log \overline{Z_{it}}\right) - s_{i,t-1}^{X}\left(\log Z_{i,t-1}^{X} - \log \overline{Z_{it}}\right),\end{aligned} \tag{A14}$$

where

$$\log \overline{Z_{it}} = \frac{\log Z_{it} + \log Z_{i,t-1}}{2}. \tag{A15}$$

In the GR decomposition, the reference group for all plants is the industry-level productivity, averaged over the beginning and end of the window. GR decomposition may be less prone to measurement error in output and inputs because of the averaging over time.

The results from the three decompositions can be found in Table A1. We see that the pattern of high contributions of net entry during the fast growth years, followed by lower contributions of net entry, still holds under all of the decompositions. For Chile, the contribution of net entry goes from 23.8 percent to 10.8 percent using GR and 22.4 percent to −50.9 percent using MP. The GR net entry contribution has been adjusted using the model so that the 1995–1998 window is comparable to other 5-year windows. The MP net entry contribution does not depend on the window length used. In the case of Korea, the contribution of net entry goes from 43.1 percent to 31.5 percent and then to 25.6 percent using GR. The contribution of net entry goes from 3.9 percent to −2.7 percent and then to −16.5 percent using MP.

**Table A1: Contributions of net entry**

| Periods | Country | FHK | GR | MP |
|---|---|---|---|---|
| 1995–1998* | Chile | 50.4 | 23.5 | 22.4 |
| 2001–2006 | Chile | 22.8 | 10.8 | −50.9 |
| 1992–1997 | Korea | 48.0 | 43.1 | 3.9 |
| 2001–2006 | Korea | 37.3 | 31.5 | −2.7 |
| 2009–2014 | Korea | 25.1 | 25.6 | −16.5 |

*Measurements adjusted to be comparable with the results from the 5-year windows.

We calculate these decompositions using output from the model. The results can be found in Table A2. The decompositions for the "reform" use model output from the 5-year window immediately after the reform. We find that the results for GR are very similar to those of FHK. This finding is consistent with Foster, Haltiwanger, and Krizan (2001), who find that the contribution of net entry to productivity growth is similar under both FHK and GR in U.S. manufacturing data. We find that both the MP and GR decompositions show an increase in the net entry contribution after the reforms.

**Table A2: Model output contributions of net entry**

| Periods | FHK | GR | MP |
|---|---|---|---|
| Reform (lower entry costs) | 59.6 | 42.8 | 24.4 |
| Reform (lower $\varphi$) | 59.6 | 42.9 | 24.4 |
| BGP | 25.0 | 15.3 | 5.9 |

### B.2. Alternative Method to Determine Production Function: Wooldridge-Levinsohn-Petrin

In our baseline specification, we use industry-level cost shares to remain consistent with FHK. As a robustness check, we use the Wooldridge (2009) extension of the Levinsohn and Petrin (2003) method (WLP) for estimation of the production function. With the new elasticities of the production function, we find the plant-level productivities and compute the FHK productivity decompositions. The contribution of net entry and aggregate manufacturing productivity growth is reported in Table A3. As before, we find a similar pattern in which the contribution of net entry is higher during periods of fast growth.

**Table A3: Net entry in manufacturing productivity decompositions (WLP)**

| Period | Country | Annual growth rate (percent) | | Contribution of net entry (percent) |
|---|---|---|---|---|
| | | Real GDP per working-age person | Aggregate productivity | |
| 1995–1998 | Chile | 4.0 | 4.4 | 73.6* |
| 2001–2006 | Chile | 2.7 | 3.4 | 45.4 |
| 1992–1997 | Korea | 6.1 | 4.3 | 39.1 |
| 2001–2006 | Korea | 4.3 | 3.5 | 39.2 |
| 2009–2014 | Korea | 3.0 | 1.4 | 23.4 |

*Results have been adjusted to be comparable with the results from the 5-year windows using the calibrated model.

### B.3. Alternative Weighting across Plants

In our baseline specification, we use gross output as weights to calculate industry productivity and then to aggregate changes in industry productivity. This methodology is consistent with that of FHK. As a robustness check, we redo the exercise using value added as weights. The results, reported in Table A4, show that the pattern still holds: The contribution of net entry is higher during periods of fast growth.

**Table A4: Net entry in manufacturing productivity decompositions (VA weights)**

| Period | Country | Annual growth rate (percent) | | Contribution of net entry (percent) |
|---|---|---|---|---|
| | | Real GDP per working-age person | Aggregate productivity | |
| 1995–1998 | Chile | 4.0 | 4.2 | 59.1* |
| 2001–2006 | Chile | 2.7 | 1.7 | −9.4 |
| 1992–1997 | Korea | 6.1 | 4.3 | 46.3 |
| 2001–2006 | Korea | 4.3 | 4.2 | 38.6 |
| 2009–2014 | Korea | 3.0 | 1.7 | 28.2 |

*Results have been adjusted to be comparable with the results from the 5-year windows using the calibrated model.

Another concern is that the results may be driven by the changing composition of industries across time — industries that consistently have a higher fraction of productivity growth accounted for by entry and exit in the FHK decomposition could also be the ones that increase their output share during periods of rapid growth. For this reason, we redo the decomposition using the same

output shares across windows. Specifically, we use the average weight across windows for each industry. The results are reported in Table A5. Using these alternative weights, we find that entry and exit still account for a larger fraction of aggregate productivity growth during periods of rapid GDP growth.

**Table A5: Net entry in manufacturing productivity decompositions (output shares averaged across windows)**

| Period | Country | Annual growth rate (percent) | | Contribution of net entry (percent) |
|---|---|---|---|---|
| | | Real GDP per working-age person | Aggregate productivity | |
| 1995–1998 | Chile | 4.0 | 6.0 | 87.4* |
| 2001–2006 | Chile | 2.7 | 1.5 | 33.4 |
| 1992–1997 | Korea | 6.1 | 5.1 | 47.2 |
| 2001–2006 | Korea | 4.3 | 4.0 | 36.8 |
| 2009–2014 | Korea | 3.0 | 1.2 | 17.4 |

*Results have been adjusted to be comparable with the results from the 5-year windows using the calibrated model.

### B.4. Analysis Considers Plants with at Least 10 Employees

The Chilean data set contains information about plants with 10 or more employees. The Korean data set covers plants with 5 or more employees for the windows 1992–1997 and 2001–2006; the data set covers plants with 10 or more employees for the window 2009–2014. We use observations with 10 or more employees when using the Korean data in order to make the analysis comparable across the two countries and windows.

In order to address the concerns that may arise from this 10-employee cutoff, we recompute the contribution of net entry using different employee cutoffs. The results of these exercises are reported in Table A6. In the first exercise, we redo the productivity decompositions using a 5-employee cutoff for the 1992–1997 and 2001–2006 windows for the case of Korea. This analysis is useful because it expands the coverage of plants and thus mitigates the concerns raised by the 10-employee cutoff. We find that the results are very similar to the baseline results, which are also shown in Table A6. We suspect that including plants with 1–4 employees would not significantly change the analysis because the market share of these plants tends to be very low. For example, manufacturing plants with 1–4 employees account for approximately 1 percent of total U.S. manufacturing employment based on calculations from the U.S. Census Longitudinal Business

Database (average 1980–2000). In the second exercise, we recompute the productivity decompositions using a cutoff of 15 employees for Chile and Korea. This exercise is useful to check whether the results are sensitive to using higher cutoffs. As before, we do not find significant changes in the contribution of net entry using this higher cutoff.

**Table A6: FHK NE contribution**

| Period | Country | Cutoff of 10 employees (baseline) | Cutoff of 5 employees | Cutoff of 15 employees |
|---|---|---|---|---|
| 1995–1998 | Chile | 50.4* | | 52.9* |
| 2001–2006 | Chile | 22.8 | | 15.5 |
| 1992–1997 | Korea | 48.0 | 46.0 | 47.9 |
| 2001–2006 | Korea | 37.3 | 37.4 | 37.6 |
| 2009–2014 | Korea | 25.1 | | 23.2 |

*Results have been adjusted to be comparable with the results from the 5-year windows using the calibrated model.

### B.5. Productivity Growth and the Contribution of Net Entry across Industries

We want to study whether industries that have high productivity growth also have a higher fraction of productivity growth that is accounted for by entry and exit. To do so, we estimate the following industry-level regression for both Chile and Korea

$$\frac{\Delta \log Z_{it}^{NE}}{\Delta \log Z_{it}} = \alpha_0 + \alpha_1 \Delta \log Z_{it} + I_t^{NE} + I_i^{NE} + \upsilon_{it}^{NE} \tag{A16}$$

where $\Delta \log Z_{it}^{NE}$ and $\Delta \log Z_{it}$ are defined in equations (2)–(4), $I_t^{NE}$ is a window fixed effect, $I_i^{NE}$ is an industry fixed effect, and $\upsilon_{it}^{NE}$ is an error term. Note that the dependent variable is the fraction of productivity growth that is attributed to net entry. For each country, we combine the industry-level information for all windows. We exclude observations with annualized growth rates of –0.2 to 0.2 percent. These observations, which represent 3 percent of the total observations for Chile and 6 percent for Korea, tend to have extremely large values for the dependent variable in equation (A16) due to the small denominator.

Table A7 presents the results of the estimation. Columns 1–4 report the results for Chile and columns 5–8 report the results for Korea. Columns 3 and 7 show the results for the specification with window and industry fixed effects for Chile and Korea, respectively. Both coefficients are

positive, although not statistically significant. Columns 4 and 8 show the results for the same specification except that we use the industry-level weights used to aggregate across industries as described in Section 2.2. This result is useful because it places greater importance on industries that are weighted more heavily in the FHK decomposition. For both Chile and Korea, the coefficient is positive, and in the case of Korea, it is also statistically significant at the 5 percent level. These results suggest that changes in the productivity growth rates within industry across time are associated with higher contributions of net entry.

In order to better understand the economic significance of the results in Table A7, consider a one standard deviation increase in industry-level productivity, $\Delta \log Z_{it}$, of 0.3 in the case of Korea. Column 8 indicates this change in correlated with an increase of 25 percentage points in the contribution of net entry.

**Table A7: Net entry and industry-level productivity growth**

| | $\Delta \log Z_{it}^{NE} / \Delta \log Z_{it}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Chile | | | | Korea | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $\Delta \log Z_{it}$ | 0.138 | 0.226 | 0.430 | 0.554 | 0.131 | 0.379*** | 0.337 | 0.819** |
| | (0.113) | (0.283) | (0.327) | (0.459) | (0.087) | (0.122) | (0.307) | (0.318) |
| Observations | 175 | 175 | 175 | 175 | 474 | 474 | 474 | 474 |
| *R*-squared | 0.008 | 0.006 | 0.702 | 0.832 | 0.010 | 0.020 | 0.387 | 0.499 |
| Weighted | No | Yes | No | Yes | No | Yes | No | Yes |
| Window FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | No | No | Yes | Yes | No | No | Yes | Yes |

Notes: Estimates of (A16) using plant-level data from Chile and Korea. Standard errors are reported in parentheses. *** Denotes $p < 0.01$ and ** denotes $p < 0.05$. Errors are clustered at the industry level.

## Appendix C: Additional Statistics

### C.1. Entering and Exiting Cohorts: Relative Productivity and Market Shares

In Section 2.2 we show that there is an increase in the contribution of net entry during periods of fast growth in Chile and Korea. We now develop a methodology to further investigate whether these results are driven by changes in the productivity of entering and exiting plants or in their market shares. In particular, we show that the FHK entry and exit terms can be decomposed into components that correspond to changes in the productivity and markets shares of entering and exiting plants.

To calculate the aggregate net entry term, we first calculate the industry-level net entry term, $\Delta \log Z_{it}^{NE}$, and then aggregate it using industry-level weights, $w_{it}$. These weights are the fraction of nominal gross output accounted for by that industry, averaged over the beginning and end of each time window. These steps are described in Section 2.2. We use the characterization of the industry-level net entry term described in (A11) and aggregate it using the industry-level weights to find the following expression:

$$\underbrace{\sum_{i=1}^{I}\left[w_{it}\Delta \log Z_{it}^{NE}\right]}_{\text{aggregate net entry term}} = \underbrace{\sum_{i=1}^{I}\left[w_{it}s_{it}^{N}\left(\log Z_{it}^{N} - \log Z_{i,t-1}\right)\right]}_{\text{aggregate entry term}} - \underbrace{\sum_{i=1}^{I}\left[w_{it}s_{i,t-1}^{X}\left(\log Z_{i,t-1}^{X} - \log Z_{i,t-1}\right)\right]}_{\text{aggregate exit term}}, \tag{A17}$$

where $I$ is the number of industries; $s_{it}^{N}$ and $\log Z_{it}^{N}$ are the gross output share and weighted average productivity, respectively, of entering plants at the end of the window; $s_{i,t-1}^{X}$ and $\log Z_{i,t-1}^{X}$ are the gross output share and the weighted average productivity, respectively, of exiting plants at the beginning of the window. We rearrange (A17) to find the following expression:

$$\underbrace{\sum_{i=1}^{I}\left[w_{it}\Delta \log Z_{it}^{NE}\right]}_{\text{aggregate net entry term}} = \underbrace{\sum_{i=1}^{I}\left[w_{it}^{N}\left(\log Z_{it}^{N} - \log Z_{i,t-1}\right)\right]}_{\text{average relative productivity of entrants}} \underbrace{\sum_{j=1}^{I} w_{jt}s_{jt}^{N}}_{\text{average entrant market share}} - \underbrace{\sum_{i=1}^{I}\left[w_{it}^{X}\left(\log Z_{i,t-1}^{X} - \log Z_{i,t-1}\right)\right]}_{\text{average relative productivity of exiters}} \underbrace{\sum_{j=1}^{I} w_{jt}s_{j,t-1}^{X}}_{\text{average exiter market share}}, \tag{A18}$$

where $w_{it}^N = w_{it} s_{it}^N \Big/ \sum_{j=1}^I w_{jt} s_{jt}^N$ and $w_{it}^X = w_{it} s_{i,t-1}^X \Big/ \sum_{j=1}^I w_{jt} s_{j,t-1}^X$. This expression allows us to determine whether changes in the entry and exit terms are driven by changes in the shares or the relative productivities. For example, in the first term we decompose the aggregate entry term into two components. First, $\log Z_{it}^N - \log Z_{i,t-1}$ is the relative productivity of entering plants in industry $i$ compared to that industry's productivity in the previous period. This measure is then aggregated using the industry-level weight, $w_{it}^N$, which is related to the gross output share of entering plants in industry $i$ relative to entering plants across all industries. Second, the market share of entering plants in industry $i$, $s_{it}^N$, is aggregated using the industry's weight, $w_{it}$. We similarly decompose the aggregate exit term.

The results of this decomposition can be found in Table 2. These results, which are discussed in Section 2.2, show that the most consistent driver of the changes in the entry and exit terms across Chile and Korea is the relative productivity of entering and exiting plants.

It is also useful to follow a similar exercise with the net entry term of the MP decomposition, which is described in (A13) of Appendix B.1. The results in Table A1 show that the net entry term of the MP decomposition also increases during periods of fast growth. We now lay out a similar strategy to study whether these changes in net entry of the MP decomposition arise from changes in productivity of entering and exiting plants or their market shares.

First, it is important to point out the differences of the net entry term in the FHK and MP decompositions. The FHK decomposition of the net entry term in (A18) compares the productivity of entering and exiting plants to the industry-level productivity at the beginning of the window. The MP decomposition, on the other hand, uses the productivity of continuing plants as a benchmark for comparison. In particular, the productivity of entrants is compared to the productivity of continuing plants at the end of the window and the productivity of exiting plants is compared to the productivity of continuing plants at the beginning of the window.

In order to calculate the aggregate MP net entry term, we first calculate the industry-level net entry term and then aggregate using the industry-level weights. We use the characterization of the industry-level net entry term described in (A13) and aggregate it using the industry-level weights to find the following expression:

$$\underbrace{\sum_{i=1}^{I}\left[w_{it}\Delta\log Z_{it}^{NE}\right]}_{\text{aggregate MP net entry term}}=\underbrace{\sum_{i=1}^{I}\left[w_{it}s_{it}^{N}\left(\log Z_{it}^{N}-\log Z_{it}^{C}\right)\right]}_{\text{aggregate MP entry term}}-\underbrace{\sum_{i=1}^{I}\left[w_{it}s_{i,t-1}^{X}\left(\log Z_{i,t-1}^{X}-\log Z_{i,t-1}^{C}\right)\right]}_{\text{aggregate MP exit term}}, \tag{A19}$$

where $\log Z_{it}^{C}$ and $\log Z_{i,t-1}^{C}$ are the weighted average productivity of continuing plants at the end and beginning of the window, respectively. We rearrange (A19) to find the following expression:

$$\underbrace{\sum_{i=1}^{I}\left[w_{it}\Delta\log Z_{it}^{NE}\right]}_{\text{aggregate MP net entry term}}=\underbrace{\sum_{i=1}^{I}\left[w_{it}^{N}\left(\log Z_{it}^{N}-\log Z_{it}^{C}\right)\right]}_{\text{average relative productivity of entrants}}\ \underbrace{\sum_{j=1}^{I}w_{jt}s_{jt}^{N}}_{\text{average entrant market share}}-\underbrace{\sum_{i=1}^{I}\left[w_{it}^{X}\left(\log Z_{i,t-1}^{X}-\log Z_{i,t-1}^{C}\right)\right]}_{\text{average relative productivity of exiters}}\ \underbrace{\sum_{j=1}^{I}w_{jt}s_{j,t-1}^{X}}_{\text{average exiter market share}}. \tag{A20}$$

Similarly, we can also aggregate the MP continuing term in equation (A13), using the same weights, to obtain

$$\sum_{i=1}^{I}\left[w_{it}\Delta\log Z_{it}^{C}\right]=\sum_{i=1}^{I}\left[w_{it}\left(\log Z_{it}^{C}-\log Z_{i,t-1}^{C}\right)\right]. \tag{A21}$$

This expression is the productivity growth of continuing plants at the industry-level, which is then aggregated using the industry-level weights.

The results are reported in Table A8. We do not see a consistent pattern in the changes of the relative productivity of entering plants for Chile and Korea. In particular, Chile saw a decline in the relative productivity of entering plants during the slow-growth window. In contrast, there was an increase in the relative productivity of entering plants in Korea when comparing the slow-growth window with the average of the two fast-growth windows.

On the other hand, in both Chile and Korea the relative productivity of exiters increased during the window of slow growth. For example, during the 1995–1998 window in Chile, the relative productivity of exiters was −2.8 percent. This number increased to 1.9 percent during the 2001–2006 window. In Korea, the relative productivity of exiters was on average −18.9 percent during the fast-growth windows. During the slow-growth window, the relative productivity of exiters was only −6.8. The relative productivity of exiters term increasing (or becoming less negative) suggests

that the selection effect weakened as growth slowed. Note that the market share of entering and exiting plants is the same as in Table 2.

It is useful to notice that columns 4–7 in Table A8 are inputs into the calculation of the contribution of net entry in the MP decomposition. In particular, the net entry contribution can be calculated as the product of the relative productivity of entering plants and their market shares (in the case of the 2001–2006 window for Chile this would be −12.8×0.36) subtracted by the product of the relative productivity of exiting plants and their market shares (1.9×0.23), which is then divided by the aggregate productivity growth (9.8). In the case of Chile this calculation gives −51 percent, which is consistent with the results in Table A1. Similarly, the contribution of continuing plants in the MP decomposition can be calculated using the information in this table. In this case, it would be the productivity growth of continuing plants divided by the aggregate productivity growth (14.8÷9.8), or 151 percent.

**Table A8: Relative productivity and market share of entering and exiting plants**

| Period | Aggregate manufacturing productivity growth (percent) | Productivity growth of continuing plants (percent) | Relative productivity of entrants (percent) | Market share of entrants | Relative productivity of exiters (percent) | Market share of exiters |
|---|---|---|---|---|---|---|
| Chile | | | | | | |
| 1995–1998* | 17.6 | 13.6 | 14.0 | 0.24 | −2.8 | 0.20 |
| 2001–2006 | 9.8 | 14.8 | −12.8 | 0.36 | 1.9 | 0.23 |
| Korea | | | | | | |
| 1992–1997 | 19.5 | 18.7 | −11.8 | 0.38 | −14.8 | 0.35 |
| 2001–2006 | 17.7 | 18.2 | −22.3 | 0.27 | −23.0 | 0.24 |
| 2009–2014 | 7.7 | 8.9 | −10.9 | 0.27 | −6.8 | 0.24 |

*Measurements adjusted to be comparable with the results from the 5-year windows.

Notes: The productivity growth of continuing plants reports equation (A21). The relative productivity of entrants compares the productivity of entering plants to that of continuing plants at the end of the window. The relative productivity of exiters compares the productivity of exiting plants to that of continuing plants at the beginning of the window. The entrant and exiter market shares are computed as in equation (A20).

### C.2. Entry and Exit Rates

Table 2 in Section 2.3 shows the market share of entering and exiting plants during the windows we study (Table A8 in Appendix C.1 also contains this information). Additionally, it is useful to examine other statistics, such as the entry and exit rate of plants, to see if they changed in a manner

similar to that of market shares during periods of fast and slow growth. Column 2 of Table A9 shows the entry rate of plants for all the windows in Chile and Korea and column 3 shows the exit rate. The changes in the entry and exit rates in both countries are qualitatively similar to the changes in the market share of entrants and exiters, respectively. As an additional check, we report the annual entry and exit rates averaged over the entire window in columns 4 and 5, respectively. The changes in the annual rates are also similar to those of the entire window with the main difference being that the annual rates are smaller.

**Table A9: Entry and exit rates**

| Period | Entry rate (entire window) | Exit rate (entire window) | Annual entry rate (averaged over window) | Annual exit rate (averaged over window) |
|---|---|---|---|---|
| Chile | | | | |
| 1995–1998 | 0.371* | 0.400* | 0.097 | 0.103 |
| 2001–2006 | 0.415 | 0.415 | 0.132 | 0.131 |
| Korea | | | | |
| 1992–1997 | 0.702 | 0.703 | 0.351 | 0.353 |
| 2001–2006 | 0.625 | 0.584 | 0.283 | 0.267 |
| 2009–2014 | 0.584 | 0.511 | 0.244 | 0.224 |

*Measurements adjusted to be comparable with the results from the 5-year windows.

Notes: The entry rate is calculated as the number of entering plants divided by the number of plants at the end of the window. The exit rate is calculated as the number of exiting plants divided by the number of plants at the beginning of the window. We follow a similar process to calculate the annual entry and exit rate.

## Appendix D: Proof of Proposition 1

The proof of Proposition 1 involves guessing and verifying the existence of an equilibrium with a balanced growth path.

From the first-order condition of the consumer and applying the balanced growth path conditions ($C_{t+1}/C_t = g_e$), we obtain $q_{t+1} = \beta/g_e$. Next, using the zero-profit condition, we can derive

$$w_t = \alpha\left(\frac{1-\alpha}{\lambda f}\right)^{1-\alpha}\hat{x}_t, \tag{A22}$$

where

$$\lambda = g_e^t / Y_t, \tag{A23}$$

which is constant on the balanced growth path. The labor market clearing condition gives

$$1 = \left(\frac{w_t}{\alpha}\right)^{\frac{1}{\alpha-1}} \frac{\gamma(1-\alpha)}{\gamma(1-\alpha)-1}\hat{x}_t^{\frac{1}{1-\alpha}}\eta_t. \tag{A24}$$

Substituting (A22) into (A24), we obtain the expression for the mass of operating firms:

$$\eta = \frac{\gamma(1-\alpha)-1}{\gamma\lambda f}. \tag{A25}$$

Using equation (18) and applying the balanced growth path conditions ($\mu_t = \mu, Y_{t+1}/Y_t = g_e, g_{ct} = \bar{g}g_e^{\varepsilon}$), we obtain the expression for the entry-exit threshold,

$$\hat{x}_t = \frac{{g_e}^t}{\varphi}\left(\frac{\omega\mu}{\eta}\right)^{\frac{1}{\gamma}}, \tag{A26}$$

where

$$\omega = \sum_{i=1}^{\infty}(1-\delta)^{i-1}\left(\frac{g_e}{g_c}\right)^{\gamma(1-i)}. \tag{A27}$$

The free-entry condition in (16) can be rewritten as

$$\kappa_t = \sum_{i=1}^{\infty}(1-\delta)^{i-1}\left(\prod_{s=1}^{i-1}q_{t+s}\right)\int_{\hat{x}_{t+i-1}\prod_{s=1}^{i-1}g_{c,t+s}^{-1}}^{\infty} d_{t+i-1}\left(\prod_{s=1}^{i-1}g_{c,t+s}x\right)dF_t(x). \tag{A28}$$

Evaluating the integral in (A28) and substituting (A24), we obtain

$$\kappa_t = \sum_{i=1}^{\infty}(1-\delta)^{i-1}\left(\prod_{s=1}^{i-1} q_{t+s}\right)\varphi^{-\gamma} {g_e}^{\gamma t}\hat{x}_{t+i-1}^{-\gamma}\prod_{s=1}^{i-1} g_{c,t+s}^{\gamma}\left\{\frac{w_{t+i-1}}{\alpha}\frac{1-\alpha}{\eta} - f_t\right\}. \tag{A29}$$

Substituting $Y_{t+i-1} = w_{t+i-1}/\alpha$ and (A25) into (A29), we obtain

$$w_t\lambda\kappa = \frac{{g_e}^{\gamma t}}{\gamma\eta}\sum_{i=1}^{\infty}(1-\delta)^{i-1}\left(\prod_{s=1}^{i-1} q_{t+s} g_{c,t+s}^{\gamma}\right) w_{t+i-1}\hat{x}_{t+i-1}^{-\gamma}. \tag{A30}$$

Substituting (A26) into (A30) and applying the balanced growth path conditions ($w_{t+1}/w_t = g_e, q_{t+1} = \beta/g_e,\ g_{ct} = g_c$), we obtain

$$\mu = \frac{\xi}{\gamma\lambda\kappa\omega}, \tag{A31}$$

where

$$\xi = \sum_{i=1}^{\infty}\beta^{i-1}(1-\delta)^{i-1}\left(\frac{g_e}{g_c}\right)^{\gamma(1-i)}. \tag{A32}$$

Finally, substituting $Y_t = w_t/\alpha$ into (A23) and applying the balanced growth path conditions, we obtain

$$\lambda = \left(\frac{f}{1-\alpha}\right)^{\frac{\gamma(1-\alpha)-1}{\alpha\gamma}}\varphi^{\frac{1}{\alpha}}\left[\frac{\kappa}{\xi}\frac{\gamma(1-\alpha)-1}{1-\alpha}\right]^{\frac{1}{\alpha\gamma}}, \tag{A33}$$

which is increasing in $\kappa$, $\varphi$, and $f$.

Thus, our guess has been verified and all optimality conditions are satisfied. □

**Appendix E: Measuring Capital in the Model**

We construct a measure of capital at the firm level in order to estimate productivity using the model output in the same manner as we did with the data, which is described in Section 2.2.

When a firm enters at time $t$, its investment is $f_t + \kappa_t$. Subsequently, its investment each period is the fixed continuation cost. Capital, $k_t$, evolves as follows:

$$k_{t+1} = (1 - \tilde{\delta}_{kt})k_t + I_t, \tag{A34}$$

where $\tilde{\delta}_{kt}$ is the depreciation rate and $I_t$ is investment at time $t$. When a firm enters at time $t$, its capital stock is $k_t = \kappa_t + f_t$. If the depreciation rate is

$$\tilde{\delta}_{kt} = \frac{f_t - (\kappa_{t+1} - \kappa_t)}{\kappa_t + f_t}, \tag{A35}$$

then the subsequent capital stock is

$$k_t = k_t + f_t, \tag{A36}$$

for all $t$ after entry. Note that the total depreciation in a given period is

$$\tilde{\delta}_{kt}(\kappa_t + f_t) = f_t - (\kappa_{t+1} - \kappa_t). \tag{A37}$$

This expression implies that the total depreciation of capital at the firm level is the fixed continuation cost minus any increase in the fixed capital stock. The fact that all firms have the same capital stock is counterfactual but allows us to keep the model analytically tractable.

We now define the aggregate depreciation rate and the aggregate capital stock. Aggregate investment is $\mu_t\kappa_t + \eta_t f_t$, and the aggregate capital stock is $\eta_t(\kappa_t + f_t) + (\mu_t - \eta_{1t})\kappa_t$. The depreciation of capital is the sum of the capital of firms that die, entry costs of failed entrants, and $f_t - (\kappa_{t+1} - \kappa_t)$ for continuing firms as discussed above. We find that the aggregate depreciation rate is

$$\delta_{kt} = 1 - \frac{\eta_{t+1}(\kappa_{t+1} + f_{t+1}) + (\mu_{t+1} - \eta_{1t+1})\kappa_{t+1}}{\eta_t(\kappa_t + f_t) + (\mu_t - \eta_{1t})\kappa_t} + \frac{\mu_t\kappa_t + \eta_t f_t}{\eta_t(\kappa_t + f_t) + (\mu_t - \eta_{1t})\kappa_t}. \tag{A38}$$

Notice that this depreciation rate is constant on the balanced growth path but not in the transition.

## Appendix F: Fixed Costs Denominated in Terms of Labor

In this section, we change our baseline model so that the fixed costs are denominated in terms of labor. We then calibrate the new model and redo the quantitative exercise in Section 7.

### F.1. Model

All of the equations that characterize the model in Section 3 remain the same except for the equations that we now characterize. Potential entrants pay an entry cost, $\kappa$, which is denominated in units of labor to draw a marginal efficiency, $x$. The condition in (9) becomes

$$d_t(x) = \max_{\ell} x\ell_t(x)^{\alpha} - w_t\ell_t(x) - w_t f, \tag{A39}$$

where $f$ is the fixed continuation cost paid in units of labor. The mass of potential entrants, $\mu_t$, characterized by (16) becomes

$$E_x\left[V_t(x)\right] = w_t\kappa. \tag{A40}$$

The labor market condition, characterized by (20), becomes

$$1 = \sum_{j=1}^{\infty}\left[\mu_{t+j-1}\left(1-\delta\right)^{j-1}\int_{\hat{x}_{jt}}^{\infty}\ell_t(x)dF_{t+j-1}\left(x/\tilde{g}_{jt}\right)\right] + \eta_t f + \mu_t\kappa. \tag{A41}$$

The goods market clearing condition, characterized by (21), becomes

$$C_t = Y_t = \sum_{j=1}^{\infty}\left[\mu_{t+j-1}\left(1-\delta\right)^{j-1}\int_{\hat{x}_{jt}}^{\infty}x\ell_t\left(x\right)^{\alpha}dF_{t-j+1}\left(x/\tilde{g}_{jt}\right)\right]. \tag{A42}$$

Aggregate dividends, characterized by (22), become

$$D_t = \sum_{j=1}^{\infty}\left[\mu_{t+j-1}\left(1-\delta\right)^{j-1}\int_{\hat{x}_{jt}}^{\infty}d_t(x)dF_{t-j+1}\left(x/\tilde{g}_{jt}\right)\right] - \mu_t w_t\kappa. \tag{A43}$$

### F.2. Balanced Growth Path

Under the new formulation, we can show a proposition similar to Proposition 1 in which (23) is satisfied along with $q_{t+1} = \beta / g_e$, $\mu_t = \mu$, $\eta_t = \eta$. The equations that characterize the balanced growth path become

$$\hat{x}_t = \frac{g_e^t}{\varphi}\left(\frac{\omega\mu}{\eta}\right)^{\frac{1}{\gamma}}, \tag{A44}$$

$$w_t = \alpha\left(\frac{1-\alpha}{\alpha f}\right)^{1-\alpha}\hat{x}_t, \tag{A45}$$

$$Y_t = \psi\alpha\left(\frac{1-\alpha}{\alpha f}\right)^{1-\alpha}\hat{x}_t, \tag{A46}$$

$$\mu = \frac{\xi}{\gamma\kappa\omega}\psi, \tag{A47}$$

$$\eta = \frac{\gamma(1-\alpha)-1}{\gamma f}\psi, \tag{A48}$$

$$\psi = \frac{\gamma\omega}{(\gamma-1)\omega+\xi}. \tag{A49}$$

As before, the efficiency cutoffs, real wages, and output grow at rate $g_e - 1$. The mass of potential entrants, $\mu$, and the mass of operating firms, $\eta$, are also constant on the balanced growth path.

**F.3. Measurement**

As in our baseline, we treat fixed costs as investment. When a firm enters at time $t$, its nominal investment is $w_t(f+\kappa)$. The firm's real investment is $I_t = w_0 g_e^t(f+\kappa)$, where $w_0$ is the base year wages, and $g_e^t$ reflects improvements in the quality of capital. After a firm enters, nominal investment each period is the fixed continuation cost $w_t f$ and its real investment is $I_t = w_0 g_e^t f$. Real capital, $k_t$, evolves as follows:

$$k_{t+1} = (1-\tilde{\delta}_{kt})k_t + I_{t+1}, \tag{A50}$$

where $\tilde{\delta}_{kt}$ is the depreciation rate and $I_{t+1}$ is real investment at time $t+1$. When a firm enters at time $t$, its real capital stock is $k_t = w_0 g_e^{\,t}(f+\kappa)$. If the depreciation rate is

$$\tilde{\delta}_{kt} = 1 - \frac{g_e\kappa}{f+\kappa}, \tag{A51}$$

then the subsequent capital stock is

$$k_t = w_0 g_e^{\,t}(f+\kappa), \tag{A52}$$

for all $t$ after entry. As in the baseline model, the fact that all firms have the same fixed capital stock generates a clean relationship between efficiency and productivity.

### F.4. Quantitative Exercises

To calibrate the model, we follow a similar strategy as before. The calibrated parameters are reported in Table A10. One thing to note is that firm size is measured in units of variable labor, as in the baseline calibration.

**Table A10: Calibrated parameters**

| Parameter | | Value | Target |
|---|---|---|---|
| Operating cost (technological) | $f^T$ | $0.69 \times 5$ | Average U.S. establishment size: 14.0 |
| Entry cost (technological) | $\kappa^T$ | 0.57 | Entry cost/continuation cost: 0.82 |
| Tail parameter | $\gamma$ | 6.10 | S.D. of U.S. establishment size: 89.0 |
| Entrant efficiency growth | $g_e$ | $1.02^5$ | BGP growth rate of U.S.: 2 percent |
| Returns to scale | $\alpha$ | 0.67 | BGP labor share of U.S.: 0.67 |
| Death rate | $\delta$ | $1-0.960^5$ | Exiting plant employment share of U.S.: 19.3 percent |
| Discount factor | $\beta$ | $0.98^5$ | Real interest rate of U.S.: 4 percent |
| Firm growth | $g_c$ | $1.019^5$ | Effect of entry and exit on U.S. manufacturing productivity growth: 25 percent |
| Spillover term | $\varepsilon$ | 0.64 | Authors' estimate |

As before, we create distorted economies in order to study the transition dynamics when we remove distortions. We only report the results for the quantitative exercise that involve lowering entry costs, since reducing barriers to technology adoption yields similar results. In the distorted economy, we raise the entry cost to 1.53 so that income is 15 percent lower on the balanced growth path. We report the results of the reforms to entry costs in Table A11. We find that, as before, GDP and productivity growth rates increase immediately after the reform. We also see an increase in the contribution of net entry. The results are quantitatively similar to our baseline.

**Table A11: Productivity decompositions (entry cost reform)**

| Model periods (five years) | Entry cost | Real GDP growth (percent, annualized) | Aggregate productivity growth (percent, annualized) | Contribution of net entry to aggregate productivity (percent) |
|---|---|---|---|---|
| 0–3 | 1.53 | 2.0 | 1.3 | 25.0 |
| 4 (reform) | 0.57 | 4.7 | 4.3 | 56.5 |
| 5 | 0. 57 | 2.4 | 1.3 | 34.0 |
| 6 | 0. 57 | 2.2 | 1.3 | 28.0 |
| 7+ | 0. 57 | 2.0 | 1.3 | 24.9 |

## Appendix G: Model with a Composite of Variable Labor and Capital

In this section, we recalibrate the model presented in Appendix F in which fixed costs are denominated in terms of labor. We reinterpret labor in the model to be equipped labor. Equipped labor is created by a bundler that uses a Cobb-Douglas technology to combine variable labor and variable capital, both of which are owned by the household. The bundler operates under perfect competition.

The new interpretation of $\alpha$ is the span-of-control parameter in Lucas's (1978) model. We use a value of $\alpha = 0.85$, which is consistent with Gomes and Kuehn (2014) and Atkeson and Kehoe (2005). Given the new value of $\alpha$, we recalibrate all other parameters as described in Table A12. Most targets are similar to the baseline calibration. One point to make is that after normalizing the labor and capital endowments, we can calculate the targets that use employment statistics in the model, such as the average establishment size. We also set the coefficient of variable labor in the bundler's Cobb-Douglas technology so that the model matches a labor share of 0.67.

**Table A12: Calibration of model with a composite of variable labor and capital**

| Parameter | | Value | Target |
|---|---|---|---|
| Operating cost (technological) | $f^T$ | $0.25\times5$ | Average U.S. establishment size: 14.0 |
| Entry cost (technological) | $\kappa^T$ | 0.20 | Entry cost/continuation cost: 0.82 |
| Tail parameter | $\gamma$ | 13.42 | S.D. of U.S. establishment size: 89.0 |
| Entrant efficiency growth | $g_e$ | $1.02^5$ | BGP growth rate of U.S.: 2 percent |
| Span-of-control | $\alpha$ | 0.85 | Atkeson and Kehoe (2005) |
| Death rate | $\delta$ | $1-0.963^5$ | Exiting plant employment share of U.S.: 19.3 percent |
| Discount factor | $\beta$ | $0.98^5$ | Real interest rate of U.S.: 4 percent |
| Firm growth | $g_c$ | $1.019^5$ | Effect of entry and exit on U.S. manufacturing productivity growth: 25 percent |
| Spillover term | $\varepsilon$ | 0.64 | Authors' estimates |

We create a distorted economy by raising the entry cost so that income on the balanced growth path is 15 percent lower. We then conduct a reform by reducing entry costs and study the subsequent transition to the new balanced growth path. Table A13 summarizes the new results. We find that the results are qualitatively the same as before. The main difference is that the contribution

of net entry in the period of reform is higher than in the baseline case (74.0 vs. 59.6). Notice, however, that the model can still account for the positive correlation between GDP growth and the contribution of net entry.

**Table A13: Productivity decompositions (entry cost reform)**

| Model periods (five years) | Entry cost | Real GDP growth (percent, annualized) | Aggregate productivity growth (percent, annualized) | Contribution of net entry to aggregate productivity (percent) |
|---|---|---|---|---|
| 0–3 | 1.80 | 2.0 | 1.7 | 25.0 |
| 4 (reform) | 0.20 | 5.0 | 4.8 | 74.0 |
| 5 | 0.20 | 2.3 | 1.6 | 33.5 |
| 6 | 0.20 | 2.1 | 1.7 | 26.6 |
| 7+ | 0.20 | 2.0 | 1.7 | 25.0 |

## Appendix H: Imperfect Competition

In this section, we change our baseline model so that monopolistically competitive firms produce different varieties of goods. The fixed costs are denominated in terms of labor as in Appendix F. We then calibrate the new model and redo the quantitative exercise in Section 7.

### H.1. Model

All of the equations that characterize the model in Appendix F.1 remain the same except for the equations that we now characterize. Perfectly competitive final good firms purchase intermediate goods and assemble them to produce the final good. The representative final good firm solves

$$\begin{aligned} &\min_{\{y_t(\nu)\}} \int_0^{\eta_t} p_t(\nu) y_t(\nu) d\nu \\ &\text{s.t. } \left( \int_0^{\eta_t} y_t(\nu)^{\rho} d\nu \right)^{\frac{1}{\rho}} = Y_t, \end{aligned} \tag{A53}$$

where $p_t(\nu)$ and $y_t(\nu)$ are the price and quantity of intermediate good $\nu$ and $\eta_t$ is the measure of intermediate goods firms. The elasticity of substitution between intermediate goods is $1/(1-\rho) > 1$ and $Y_t$ is real aggregate output. Solving the final good firm's problem yields the demand function for the intermediate good $\nu$,

$$y_t(\nu) = Y_t \left( \frac{p_t(\nu)}{P_t} \right)^{\frac{-1}{1-\rho}}, \tag{A54}$$

where the price aggregator is given by

$$P_t = \left( \int_0^{\eta_t} p_t(\nu)^{\frac{-\rho}{1-\rho}} d\nu \right)^{\frac{1-\rho}{-\rho}}, \tag{A55}$$

which is normalized to 1.

Potential entrants pay an entry cost, $\kappa$, which is denominated in units of labor to draw a marginal efficiency, $x$. Firm $\nu$ in the intermediate goods sector has the production function

$$y(\nu) = x(\nu) \ell(\nu). \tag{A56}$$

Conditional on existing, firm $\nu$ solves

$$d_t(\nu) = \max_{p(\nu)} \left[ p(\nu) - \frac{w_t}{x(\nu)} \right] Y_t p_t(\nu)^{\frac{-1}{1-\rho}} - w_t f, \tag{A57}$$

where $f$ is the fixed continuation cost paid in units of labor. The solution is the usual markup over marginal cost,

$$p(\nu) = \frac{w_t}{\rho x(\nu)}. \tag{A58}$$

As every firm with productivity $x$ chooses the same price, we no longer characterize a good by its name $\nu$ but by the productivity $x$ of the firm that produces it.

The goods market clearing condition, characterized by (A42), becomes

$$C_t = Y_t = \left[ \sum_{j=1}^{\infty} \left[ \mu_{t+j-1} (1-\delta)^{j-1} \int_{\hat{x}_{jt}}^{\infty} y_t(x)^{\rho} \, dF_{t-j+1}\left(x / \tilde{g}_{jt}\right) \right] \right]^{\frac{1}{\rho}}. \tag{A59}$$

### H.2. Balanced Growth Path

Under the new formulation, we can show a proposition similar to Proposition 1 in which (23) is satisfied along with $q_{t+1} = \beta / g_e$, $\mu_t = \mu$, $\eta_t = \eta$. The equations that characterize the balanced growth path become

$$\hat{x}_t = \frac{g_e^t}{\varphi} \left( \frac{\omega \mu}{\eta} \right)^{\frac{1}{\gamma}}, \tag{A60}$$

$$w_t = \rho \left( \psi \frac{1-\rho}{f} \right)^{\frac{1-\rho}{\rho}} \hat{x}_t, \tag{A61}$$

$$Y_t = \psi \rho \left( \psi \frac{1-\rho}{f} \right)^{\frac{1-\rho}{\rho}} \hat{x}_t, \tag{A62}$$

$$\mu = \frac{\xi \rho}{\gamma \kappa \omega} \psi, \tag{A63}$$

$$\eta = \frac{\gamma(1-\rho) - \rho}{\gamma f} \psi, \tag{A64}$$

$$\psi = \frac{\gamma\omega}{(\gamma-\rho)\omega+\rho\xi}. \tag{A65}$$

As before, the efficiency cutoffs, real wages, and output grow at rate $g_e - 1$. The mass of potential entrants, $\mu$, and the mass of operating firms, $\eta$, are also constant on the balanced growth path.

### H.3. Measurement

While the model with imperfect competition has equilibrium conditions similar to those in our baseline model with perfect competition and decreasing returns to scale, there is a difference in how the model efficiencies map into measured productivities. Measured productivity in the model with imperfect competition, complicated by the fact that higher efficiency firms charge lower prices, is given by

$$\log\left(z_t(x)\right) = \log\left(p_t(x)y_t(x)\right) - \alpha_{\ell t}\log\left(\ell_t(x)\right) - \alpha_{kt}\log\left(k_t\right), \tag{A66}$$

where $\alpha_\ell$ and $\alpha_k$ are calculated as explained in Section 5 and $k_t$ is defined as in Appendix F.3. Substituting optimality conditions, we obtain

$$\log\left(z_t(x)\right) = \rho\log x + (1-\rho)\log\left(Y_t\right) - \alpha_{kt}\log\left(\kappa_t + f_t\right), \tag{A67}$$

which still has the characteristic that log productivity is an affine transformation of log efficiency.

### H.4. Quantitative Exercises

To calibrate the model, we follow a similar strategy as before, except that we set the elasticity of substitution to 3 as in Asturias et al. (2016). The calibrated parameters are reported in Table A14. Firm size is measured in units of variable labor, as in the baseline calibration and in Appendix F.

**Table A14: Calibrated parameters**

| Parameter | | Value | Target |
|---|---|---|---|
| Operating cost (technological) | $f^T$ | $0.69 \times 5$ | Average U.S. establishment size: 14.0 |
| Entry cost (technological) | $\kappa^T$ | 0.57 | Entry cost/continuation cost: 0.82 |
| Tail parameter | $\gamma$ | 4.09 | S.D. of U.S. establishment size: 89.0 |
| Entrant efficiency growth | $g_e$ | $1.02^5$ | BGP growth rate of U.S.: 2 percent |
| Elasticity of substitution | $1/(1-\rho)$ | 3.00 | Asturias et al. (2018) |
| Death rate | $\delta$ | $1-0.960^5$ | Exiting plant employment share of U.S.: 19.3 percent |
| Discount factor | $\beta$ | $0.98^5$ | Real interest rate of U.S.: 4 percent |
| Firm growth | $g_c$ | $1.019^5$ | Effect of entry and exit on U.S. manufacturing productivity growth: 25 percent |
| Spillover term | $\varepsilon$ | 0.64 | Authors' estimate |

As before, we create distorted economies in order to study the transition dynamics when we remove distortions. We only report the results for the quantitative exercise that involve lowering entry costs, since reducing barriers to technology adoption yields similar results. In the distorted economy, we raise the entry cost to 1.11 so that income is 15 percent lower on the balanced growth path. We report the results of the reforms to entry costs in Table A15. We find that, as before, GDP and productivity growth rates increase immediately after the reform. We also see an increase in the contribution of net entry. The results are quantitatively similar to our baseline.

**Table A15: Productivity decompositions (entry cost reform)**

| Model periods (five years) | Entry cost | Real GDP growth (percent, annualized) | Aggregate productivity growth (percent, annualized) | Contribution of net entry to aggregate productivity (percent) |
|---|---|---|---|---|
| 0–3 | 1.11 | 2.0 | 1.3 | 25.0 |
| 4 (reform) | 0.57 | 4.2 | 3.7 | 48.1 |
| 5 | 0. 57 | 2.8 | 1.7 | 29.5 |
| 6 | 0. 57 | 2.3 | 1.5 | 26.6 |
| 7+ | 0. 57 | 2.0 | 1.3 | 25.0 |

## Appendix I: Model with Idiosyncratic Growth Shocks

In this section, we change our baseline model so that incumbent efficiency growth is subject to idiosyncratic shocks. We then calibrate the new model and redo the quantitative exercise in Section 7. Our findings indicate that the two models—the idiosyncratic growth shock model and the baseline model—behave similarly as long as the average growth rate of continuing firms is calibrated so that entry and exit account for the same proportion of productivity growth.

### I.1. Model

The equations characterizing the model in Section 3 remain the same except for the equations described below. We modify the model such that continuing firms' productivity grows by $g_{ht}$ with probability $p$ and grows by a lower $g_{lt} \leq g_{ht}$ with probability $1-p$. This implies that the value of a firm with efficiency $x$ is

$$V_t(x) = \max\left\{d_t(x) + q_{t+1}(1-\delta)\left[pV_{t+1}\left(xg_{h,t+1}\right) + (1-p)V_{t+1}\left(xg_{l,t+1}\right)\right], 0\right\}. \tag{A68}$$

We continue with the formulation in (12) in which firms benefit from spillovers from the rest of the economy. In particular, $g_{ht}$ and $g_{lt}$ are determined by the following equations:

$$g_{ht} = \overline{g}_h g_t^{\varepsilon}, \tag{A69}$$

$$g_{lt} = \overline{g}_l g_t^{\varepsilon}, \tag{A70}$$

where $\overline{g}_h$ and $\overline{g}_l$ are constants that satisfy $\overline{g}_h \geq \overline{g}_l$, $g_t$ is the growth factor of the unweighted mean efficiency of all firms that operate, and $\varepsilon$ measures the degree of spillovers from the aggregate economy as defined in the baseline model.

The mass of firms of age $j$ in operation, $\eta_{jt}$, given in equation (17) becomes

$$\eta_{jt} = \mu_{t+1-j}(1-\delta)^{j-1}\left(1 - G_{jt}\left(\hat{x}_{jt}\right)\right), \tag{A71}$$

where $G_{jt}(x)$ characterizes the efficiency distribution of firms of age $j$ at time $t$ and is as follows:

$$1 - G_{jt}(x) = \prod_{k=1}^{j-1}\left[pg_{h,t-k+1}^{\gamma} + (1-p)g_{l,t-k+1}^{\gamma}\right]\left[1 - F_{t-j+1}(x)\right]. \tag{A72}$$

This expression can be obtained by recursively applying

$$1-G_{jt}\left(x\right)=p\left[1-G_{j-1,t-1}\left(\frac{x}{g_{ht}}\right)\right]+\left(1-p\right)\left[1-G_{j-1,t-1}\left(\frac{x}{g_{lt}}\right)\right], \tag{A73}$$

noting that $G_{1t}\left(x\right)=F_t\left(x\right)$.

### I.2. Balanced Growth Path

The analytical characterizations of the FHK decompositions along the balanced growth path, given in equations (36)–(38) become

$$\frac{\Delta\log Z^{Entry}}{\Delta\log Z}=1-(1-\delta)\left[p\left(\frac{g_h}{g_e}\right)^{\gamma}+\left(1-p\right)\left(\frac{g_l}{g_e}\right)^{\gamma}\right], \tag{A74}$$

$$-\frac{\Delta\log Z^{Exit}}{\Delta\log Z}=\left(1-\delta\right)\left[\begin{array}{l}p\left(\frac{g_h}{g_e}\right)^{\gamma-\frac{1}{1-\alpha}}\frac{\log\left(g_e\right)-\log\left(g_h\right)}{\left(1-\alpha_k\right)\log\left(g_e\right)}\\+\left(1-p\right)\left(\frac{g_l}{g_e}\right)^{\gamma-\frac{1}{1-\alpha}}\frac{\log\left(g_e\right)-\log\left(g_l\right)}{\left(1-\alpha_k\right)\log\left(g_e\right)}\end{array}\right], \tag{A75}$$

$$\frac{\Delta\log Z^{C}}{\Delta\log Z}=(1-\delta)\left\{\begin{array}{l}p\left(\frac{g_h}{g_e}\right)^{\gamma-\frac{1}{1-\alpha}}\left[\left(\frac{g_h}{g_e}\right)^{\frac{1}{1-\alpha}}-\frac{\log(g_e)-\log(g_h)}{\left(1-\alpha_k\right)\log(g_e)}\right]\\+\left(1-p\right)\left(\frac{g_l}{g_e}\right)^{\gamma-\frac{1}{1-\alpha}}\left[\left(\frac{g_l}{g_e}\right)^{\frac{1}{1-\alpha}}-\frac{\log\left(g_e\right)-\log\left(g_l\right)}{\left(1-\alpha_k\right)\log\left(g_e\right)}\right]\end{array}\right\}. \tag{A76}$$

Note that if we set $p=0$ and $g_l=g_c$ then (A74)–(A76) are identical to (36)–(38).

Finally, the constant terms, $\omega$ and $\xi$, in Proposition 1 become

$$\omega=\sum_{i=1}^{\infty}\left(1-\delta\right)^{i-1}g_e^{\gamma(1-i)}\left[pg_h^{\gamma}+\left(1-p\right)g_l^{\gamma}\right]^{i-1}, \tag{A77}$$

$$\xi=\sum_{i=1}^{\infty}\left(1-\delta\right)^{i-1}\beta^{i-1}g_e^{\gamma(1-i)}\left[pg_h^{\gamma}+\left(1-p\right)g_l^{\gamma}\right]^{i-1}. \tag{A78}$$

### I.3. Quantitative Exercises

To calibrate the model, we first set $\overline{g}_h = g_e^{1-\varepsilon}$. This value of $\overline{g}_h$ implies that on the balanced growth path, high-growth firm efficiencies grow at the same rate as the aggregate economy, $g_e$. As a starting point, we set $p = 0.5$ and explore alternative values of $p$ in the next subsection. The calibration strategy is similar to the one described in Table 4, with the exception that the $g_l$ parameter is set so that the model matches the FHK contribution of entry and exit to U.S. manufacturing productivity growth of 25 percent. Table A16 reports the calibrated parameters.

**Table A16: Calibration of model with idiosyncratic growth shocks for $p = 0.50$**

| Parameter | | Value | Target |
|---|---|---|---|
| Operating cost (technological) | $f^T$ | 0.46×5 | Average U.S. establishment size: 14.0 |
| Entry cost (technological) | $\kappa^T$ | 0.38 | Entry cost/continuation cost: 0.82 |
| Tail parameter | $\gamma$ | 6.10 | S.D. of U.S. establishment size: 89.0 |
| Entrant efficiency growth | $g_e$ | $1.02^5$ | BGP growth rate of U.S.: 2 percent |
| Returns to scale | $\alpha$ | 0.67 | BGP labor share of U.S.: 0.67 |
| Death rate | $\delta$ | $1 - 0.96^5$ | Exiting plant employment share of U.S.: 19.3 percent |
| Discount factor | $\beta$ | $0.98^5$ | Real interest rate of U.S.: 4 percent |
| Low growth | $g_l$ | $1.018^5$ | FHK contribution of entry and exit to U.S. manufacturing productivity growth: 25 percent |
| Spillover term | $\varepsilon$ | 0.64 | Authors' estimate |

We study the properties of the transition path by creating a distorted economy with higher entry costs. Table A17 reports the results of the transition after conducting a reform in this distorted economy. We find that, as before, GDP and productivity growth rates increase immediately after the reform. We also see an increase in the contribution of net entry. The results are very similar to those of the baseline case reported Table 6 and are identical up to the first decimal digit. Reducing barriers to technology adoption yields results similar to those in Table A17.

**Table A17: Productivity decompositions for $p = 0.50$ (entry cost reform)**

| Model periods (five years) | Entry cost | Real GDP growth (percent, annualized) | Aggregate productivity growth (percent, annualized) | Contribution of net entry to aggregate productivity (percent) |
|---|---|---|---|---|
| 0–3 | 0.74 | 2.0 | 1.3 | 25.0 |
| 4 (reform) | 0.38 | 4.6 | 2.9 | 59.6 |
| 5 | 0.38 | 2.5 | 1.5 | 36.5 |
| 6 | 0.38 | 2.1 | 1.3 | 28.1 |
| 7+ | 0.38 | 2.0 | 1.3 | 25.0 |

## I.4. Further Exploring Quantitative Results

The quantitative results from the baseline model and the model with idiosyncratic growth shocks are remarkably similar. In order to better understand the implications of these idiosyncratic growth shocks, we calibrate the model using different values of $p$, ranging from 0 to 0.95. Table A18 reports the values of $p$ and the corresponding value of $g_l$ that emerge from the calibration. Note that higher values of $p$ (that is, a larger fraction of high-growth firms) require lower $g_l$ in order to match the FHK net entry contribution to productivity growth of 25 percent. Furthermore, the case of $p = 0$ and $g_l = 1.019^5$ corresponds to the baseline case, meaning that all continuing firms have the same productivity growth and this growth is the same as $g_c$ in the baseline case.

**Table A18: FHK decompositions in the balanced growth path**

| FHK decomposition (BGP) | Probability of high growth | | | | | |
|---|---|---|---|---|---|---|
| | (Baseline) $p = 0$ $g_l = 1.019^5$ | $p = 0.25$ $g_l = 1.019^5$ | $p = 0.5$ $g_l = 1.018^5$ | $p = 0.75$ $g_l = 1.017^5$ | $p = 0.90$ $g_l = 1.011^5$ | $p = 0.95$ $g_l = 0.997^5$ |
| Net entry | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| Entry | 20.3 | 20.3 | 20.3 | 20.3 | 20.2 | 20.2 |
| Exit | –4.7 | –4.7 | –4.7 | –4.7 | –4.8 | –4.8 |
| Continuing | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 |
| Within | 75.9 | 75.9 | 75.9 | 75.9 | 75.9 | 75.8 |
| Covariance | –0.9 | –0.9 | –0.8 | –0.7 | –0.3 | 0.6 |
| Between | –0.1 | –0.1 | –0.1 | –0.2 | –0.6 | –1.4 |

In order to study our quantitative results more closely, we further break down the continuing term described in (5), $\Delta \log Z_{it}^{C}$, in the same manner as FHK as follows:

$$\Delta \log Z_{it}^{C} = \underbrace{\sum_{e \in C_{it}} s_{ei,t-1} \Delta \log z_{et}}_{\text{within term}} + \underbrace{\sum_{e \in C_{it}} \Delta \log z_{et} \Delta s_{et}}_{\text{covariance term}} + \underbrace{\sum_{e \in C_{it}} \left( \log z_{e,t-1} - \log Z_{i,t-1} \right) \Delta s_{et}}_{\text{between term}}. \qquad \text{(A79)}$$

The within term remains the same as before. The reallocation term is broken down into the covariance and between terms. The covariance term measures productivity growth that is accounted for by a positive covariance of changes in productivity and market shares (for example, firms with increasing productivity also see an increase in market shares). The between term measures productivity growth that is due to changing shares across firms (for example, firms that are relatively productive at the beginning of the window see an increase in market share).

Table A18 reports the sub-components of the continuing term and the net entry term on the balanced growth path for the idiosyncratic growth-shocks model and the baseline model. In the first row, we see that the contribution of net entry, which is a calibrated target, is 25 percent in all cases. The breakdown of the contributions of net entry shows that the entry and exit contributions are stable across the various specifications. Thus, the model with idiosyncratic growth shocks does not significantly change the composition of the net entry term on the balanced growth path.

The fourth row of the table indicates the contribution of the continuing term. The breakdown of the continuing term shows that the within term is very stable even with different values of $p$. The breakdown also shows that there are changes in the covariance term. In the baseline model, the covariance term is negative because the productivity of continuing firms increases, while their market shares decline. In order to understand why this is the case, it is useful to study the market share of a firm with efficiency $x$ in the model, which is given by

$$s_t(x) = \left( \frac{\alpha x}{w_t} \right)^{\frac{1}{1-\alpha}}. \qquad \text{(A80)}$$

Thus, changes in the market share of a firm depend on the growth of the firm's efficiency compared to the growth in wages. On the balanced growth path, $w_t$ grows by $g_e$ whereas continuing firms' efficiencies grow by $g_c < g_e$. Why is it that there is an increase in the covariance term with an increase in $p$? First, it is important to note that the efficiency of high-growth firms grows at

$g_h = g_e$, implying that the market share of the high-growth firms remains the same, or $\Delta s_{et} = 0$. Similarly, the market share of the low-growth firms declines because $g_l < g_h$, which implies that $\Delta s_{et} < 0$. Furthermore, for very large $p$ we get that $\Delta \log z_{et} < 0$ for the low-growth firms. For example, when $p = 0.95$ we find that $g_l = 0.997^5$, which implies that the low-growth firms experience productivity losses. These two results would yield a positive covariance term for large enough $p$.

We also see that the between term becomes increasingly negative as $p$ increases. Note that in the baseline model the between term is negative. The reason is that the market share of continuing firms declines, $\Delta s_{et} < 0$, because $g_c < g_e$. Furthermore, the selection effect implies that the set of continuing firms are on average more productive than the set of all firms, which includes exiting firms. Hence, $\sum_{e \in C_{it}} \left( \log z_{e,t-1} - \log Z_{i,t-1} \right) > 0$. Why is it that the within term declines with an increase in $p$? As before, the market share of the high-growth firms remains unchanged because $g_h = g_e$ and the market share of the low-growth firms declines because $g_l < g_h$. For the low-growth productivity firms, as $p$ increases $\Delta s_{et}$ becomes increasingly negative. The reason is that a higher $p$ implies a lower $g_l$ in the calibrated model.

Finally, the transition dynamics when we calibrate the model to the different values of $p$ are very similar to the transition dynamics when $p = 0.5$ as reported in Table A17. For example, when $p = 0.95$, the contribution of net entry in the transition rises to 59.5 percent.

## Appendix J: Common productivity increase

In this section, we investigate the effects of a common productivity increase for potential entrants and incumbents.[9] In this case, the annualized efficiency growth rate of potential entrants rises from 2.0 to 5.4 percent and that of incumbents rises from 1.9 to 5.3 percent during the reform period.

We report the results of this exercise in Table A19. We find that, as before, GDP and productivity growth rates increase immediately after the reform. During the reform period, the economy immediately jumps to the higher balanced growth path. Both entrants and incumbents experience efficiency growth rates that are 3.4 percentage points (annualized) higher than during the balanced growth paths. As a result, there are no changes in entry or exit rates. In terms of the FHK decomposition, both the FHK entry and continuing terms increase by the same magnitude. The FHK exit term, on the other hand, remains the same because neither the market share of exiters nor their relative productivities change. As a result, the contribution of entry and exit slightly decreases during the common productivity increase.

**Table A19: Productivity decompositions (common productivity increase)**

| Model periods (five years) | Incumbent efficiency growth (percent, annualized) | Entrant efficiency growth (percent, annualized) | Real GDP growth (percent, annualized) | Aggregate productivity growth (percent, annualized) | Contribution of net entry to aggregate productivity (percent) |
|---|---|---|---|---|---|
| 0–3 | 1.9 | 2.0 | 2.0 | 1.3 | 25.0 |
| 4 (shock) | 5.3 | 5.4 | 5.4 | 4.6 | 21.6 |
| 5 | 1.9 | 2.0 | 2.0 | 1.3 | 25.0 |
| 6 | 1.9 | 2.0 | 2.0 | 1.3 | 25.0 |
| 7+ | 1.9 | 2.0 | 2.0 | 1.3 | 25.0 |

[9] A common productivity increase for potential entrants and incumbents can be achieved by setting $\varepsilon = 1$ and recalibrating $\overline{g}$ to maintain the same contribution of entry and exit as in the baseline, and by reducing the barriers to technological adoption $\varphi$. In addition, to focus on the direct effects of the common productivity increase, we eliminate the indirect effect of $\lambda(\kappa, f, \varphi)$ described in Section 4.2 by adjusting $\kappa$ and $f$ to keep the fixed costs as a percent of output per capita constant.

**Appendix K: Sensitivity Analysis of Spillover Parameter, $\varepsilon$**

In this section, we report the sensitivity analysis when we use alternative values of the spillover parameter, $\varepsilon$. We redo the quantitative exercise using $\varepsilon$ values of 0.38 and 0.83, which are the minimum and maximum values that we found in the Chilean and Korean data as reported in Table 5. For each $\varepsilon$, we recalibrate all of the parameters using the same targets as in Table 4. In both cases, all of the parameters remain the same as in the baseline calibration except for $\overline{g}$. We then use each calibrated economy to create a distorted economy that has higher entry costs. Income is 15 percent lower on the balanced growth path in these distorted economies. As can be seen in Table A20, when we conduct a reform, we find that there is an immediate increase in the net entry term, which ranges from 46.9 to 73.9 percent (vs. 59.6 percent in the baseline case). We conclude that the model can quantitatively account for the positive correlation between output growth and the contribution of net entry for a wide range of empirically relevant values of $\varepsilon$.

**Table A20: Contribution of net entry with entry cost reform (percent)**

| Robustness | Parameter | BGP | Reform |
|---|---|---|---|
| Low spillovers | $\varepsilon = 0.38$ | 25.0 | 73.9 |
| High spillovers | $\varepsilon = 0.83$ | 25.0 | 46.9 |
| Baseline | $\varepsilon = 0.64$ | 25.0 | 59.6 |

## Appendix L: Reforms in Chile and Korea

Table A21 describes the reforms conducted in Chile (enacted 1993−1997) and Korea (enacted 1990−1995 and 1998−2004).

**Table A21: Summary of reforms in Chile and Korea**

| Country (Year) | Reform | Details | Source |
|---|---|---|---|
| Chile (1993) | FDI reforms | "The last revision of that rule [minimum permanence requirement for the equity portion of the investment] was made in 1993, when the limit was reduced from three years to one year." | OECD (2003), p. 77 |
| Chile (1993) | Financial reforms | "This law [banking regulatory reform in 1986] ... was complemented by a securities law in 1993 that increased transparency in the capital markets and regulated conflicts of interest." | Perry and Leipziger (1999), p. 113 |
| Chile (1993) | Deregulation and privatization of services | "The law [1982 regulatory law of Chilean telecoms sector] was amended ... in 1993 to allow for competition in long-distance telephone services." | Perry and Leipziger (1999), p. 358 |
| Chile (1997) | Financial reforms | "At the end of 1997 a new law widened banks' activities and set rules for the internationalization of the banking system." | Perry and Leipziger (1999), p. 113 |
| Chile (1997) | Deregulation and privatization of services | "Legislation was passed in 1997 to allow private involvement in the water and sewage sector and private management of the state-owned ports." | Perry and Leipziger (1999), p. 287 |
| Korea (1990) | Monopoly Regulation and Fair Trade Act | "The government strengthened the institutional basis to regulate unfair and anticompetitive trade practices." | Suh (2007), p. 23 |
| Korea (1991) | FDI reforms | "allowed foreign investment in manufacturing with a foreign-investment ratio not exceeding 50 percent" | Chung (2007), pp. 278-279 |
| Korea (1992) | Subsidy for high-tech firms | "The government specified 58 areas for which tax exemption [for foreign-invested firms] would apply. Among these were high-tech manufacturers." | Chung (2007), p. 279 |
| Korea (1993) | Entry and financial reforms | "a combination of deregulation of corporate entry and of the financial system" | Haggard and Mo (2000) |
| Korea (1994) | Entry reforms | "relax entry and investment restrictions in steel and semiconductor industries." | Haggard and Mo (2000) |
| Korea (1994) | Financial reforms | "The authorities lifted ceilings on short-term foreign currency borrowing by commercial banks." | Eichengreen et al. (2015), p.166 |

| | | | |
|---|---|---|---|
| Korea (1995) | FDI reforms | "raise the ceiling on foreign equity ownership of listed corporations" | Chung (2007), p. 280 |
| Korea 1998) | FDI reforms | "Ceilings on foreign investment in equities, with the exception of investment in public corporations, were then lifted." | Eichengreen et al. (2015), p.100 |
| Korea (1998) | Financial reforms | "Firms were permitted to borrow abroad on long as well as short terms, and other foreign exchange transactions were relaxed." | Eichengreen et al. (2015), p.169 |
| Korea (1998) | Financial reforms | "removed most of the restrictions on foreign exchange transactions and domestic transactions in foreign currencies" | Chung (2007), p. 281 |
| Korea (1998) | FDI reforms | "abolished ceiling on equity investment by foreigners" | Lee et al. (2007), p. 60 |
| Korea (1998) | Labor Standards Act | "Labor market reforms focused on labor market flexibility." | Lee et al. (2007), p. 75 |
| Korea (1998−2001) | Corporate governance | "adopted international accounting and auditing standards" | Lee et al. (2007), p. 60 |
| Korea (1999) | Monopoly Regulation and Fair Trade Act | "Merger-specific efficiencies now had to clearly outweigh the harmful effects of reduced competition." | Eichengreen et al. (2015), p.169 |
| Korea (1999) | Omnibus Cartel Repeal Act | "removed legal exemptions for 20 cartels and 18 statutes" | Eichengreen et al. (2015) |
| Korea (2004) | Financial reforms | "waves of financial liberalization set off in 1993, 1998, and 2004" | Eichengreen et al. (2015) |
| Korea (2004) | Second Cartel Reformation Act | "legislated to abolish anticompetitive laws and systems" | Lee et al. (2007), p. 61 |